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SURFACE-DUCT SONAR MEASUREMENTS (SUDS I - 1972) OCEANOGRAPHIC M--ETC(U)
JAN 76 E R ANDERSON
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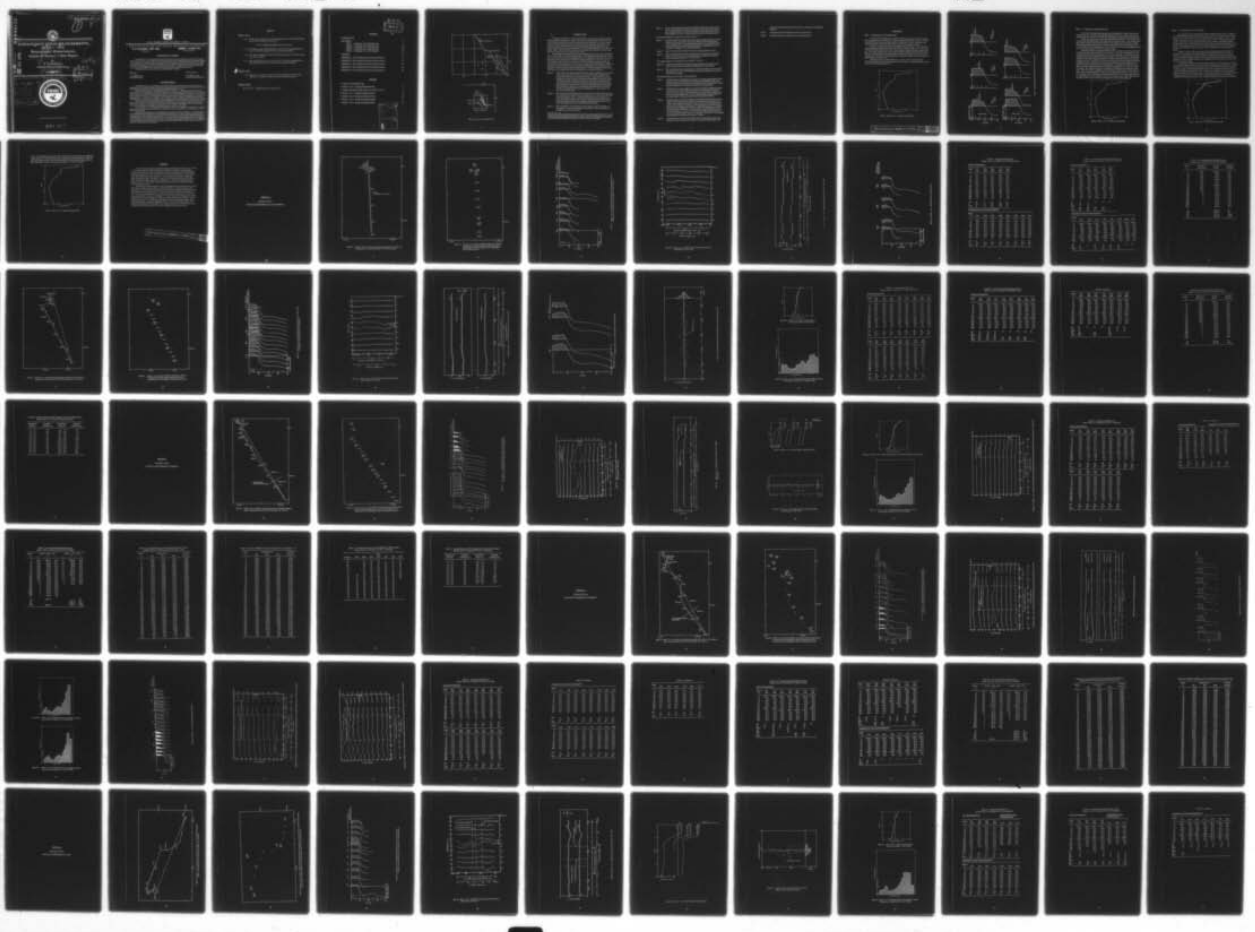

(14) NUC-TP-465 Vol-2

(1)

SURFACE-DUCT SONAR MEASUREMENTS (SUDS I - 1972)

Oceanographic Measurements, Volume II: Station 1 Data Report,

(10) by
E. R. Anderson
Undersea Sciences Department

(11) January 1976

(12) 99 p.

Research and development rept. Jan 71 - Jan 76,

(6) F52552

(7) SF5255262

390 458

NAVAL UNDERSEA CENTER, SAN DIEGO, CA. 92132

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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Commander

HOWARD L. BLOOD, PhD
Technical Director

ADMINISTRATIVE STATEMENT

During February 1972 the Naval Undersea Center conducted a series of 18 propagation loss experiments in three deep-water areas off the coast of California. These experiments are known as the SURface Duct Sonar Measurements (SUDS I – 1972). This work was originally supported by the then Naval Ships Systems Command, Sonar Technology Division, PMS-302-4 and partly supported by the Office of Naval Research, code 102-OSC. The preparation of this report began in April 1973 under the sponsorship of the Naval Sea Systems Command, code 06H1-4, problem SF 52-552-602, task 19344. This report covers work from March 1971 to January 1976 and was approved for publication in March 1976.

Technical reviewers for this report were M. A. Pedersen and P. G. Hansen.

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ACKNOWLEDGMENTS

The SUDS I program was a coordinated and cooperative effort involving personnel from the Undersea Sciences Department and the Undersea Surveillance Department. Also participating in the oceanographic measurement program were personnel from the Lockheed Ocean Laboratory (Lockheed Missiles and Space Co., Inc.).

The Principal Investigator for the SUDS experiments was J. Cummins. P. G. Hansen and K. W. Nelson were the Senior Scientists for the oceanographic measurements program. D. P. Hamm was the Principal Investigator for the Lockheed Ocean Laboratory. The Lockheed Ocean Laboratory, with L. P. Coates as Program Manager, constructed the Teletherm buoy system, operated the system at sea, and provided the initial reduction of the data. The following assisted in a consulting and planning capacity: E. R. Anderson, P. A. Barakos, O. S. Lee, and W. F. Potter. Assisting in the preliminary data reduction and analysis was J. L. Thompson, an exchange scientists from Royal Australian Navy Research Laboratory, Sidney, Australia.

H. P. Bucker was the Scientist-in-Charge aboard the *DeSteiguer*, D. E. Good, the Scientist-in-Charge aboard the *Lee*, and P. A. Hanson, the Scientist-in-Charge aboard the *Cape*. Assisting with the oceanographic measurements at sea were: A. E. Diamond, H. L. Haskall, C. T. Smallenberger, and W. M. Woods. The assistance of the officers and men of the *DeSteiguer*, *Lee*, and *Cape* in making the oceanographic measurements program a success is acknowledged.

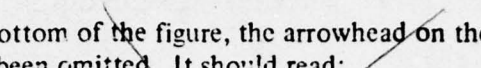
C. L. Barker and C. D. Curtis calibrated the Teletherm buoy sensors, K. W. Nelson, S. L. Speidel, and G. L. Crutcher assisted in the data reduction and computer aspects of the work, and O. S. Lee supervised the spectral analysis of the Wave-rider buoy measurements.

Additional acknowledgments are: Pacific Missile Range, Geophysics Division, Point Mugu, CA, which furnished the Datawell Waverider buoy system; Fleet Numerical Weather Central, Monterey, CA, which furnished the expendable bathy-thermograph probes; Fleet Weather Facility, San Diego, CA, which arranged for air-dropped expendable bathythermographs in the SUDS I areas prior to the ships moving from station 2 to station 3; the Naval Oceanographic Office, Pacific Support Group, San Diego, CA, which provided personnel to make environmental measurements and assistance aboard the *DeSteiguer*; and the Naval Electronics Laboratory Center, Communications Facilities Support Branch, which provided the shore-based portions of the ship-to-shore communications.

ERRATA

TP 464, Vol. II

p. 46 At the bottom of the figure, the arrowhead on the left end of the horizontal line has been omitted. It should read:



p. 58 The apparent data points at a range of 12 to 14 kyd and a propagation loss level of 123 dB are not real, but merely accidents of printing.

p. 67 The symbol for the noise level of 125 dB has been omitted. It was measured at a range of 36.0 kyd.

p. 72 The apparent data points at a range of 13 to 15 kyd and a propagation loss level of 131 dB are not real. These are also accidents of printing.

* TP 465, Vol. II

p. 48 Figure C-6. The label at the top of the figure should read "distance from receivers, kyd" instead of "distance between measurements, kyd."

TP 465, Vol. III

pp. 29, 42, 59 Column heading "C" should be "$\bar{C}$."

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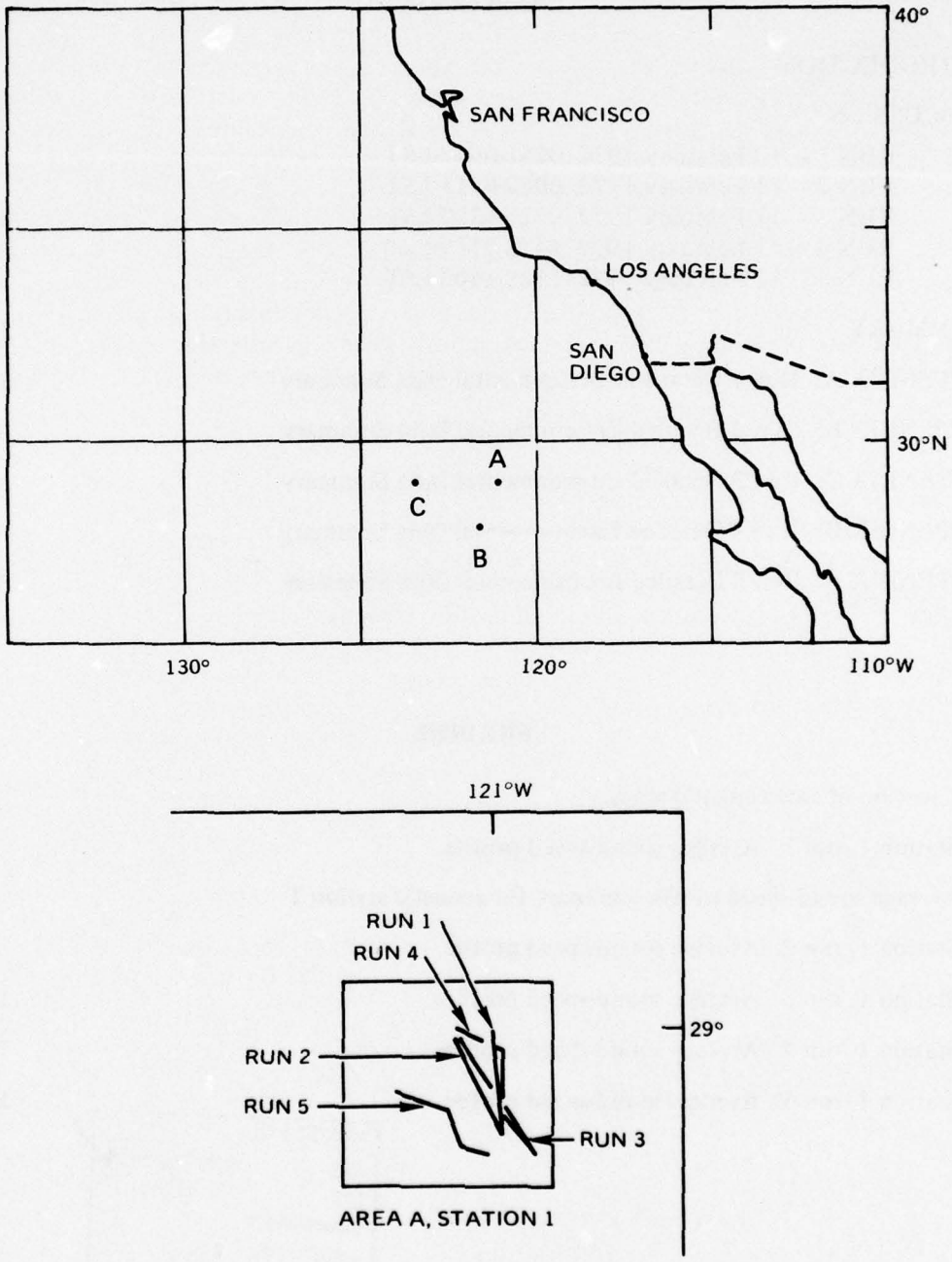

Figure 1. Location of experimental areas.

INTRODUCTION

This is the second of five volumes describing the environmental measurements made during the SUDS I experiments. Volume I discusses the instrumentation used to make the required environmental measurements, the data reduction procedures, an accuracy analysis of the final measurements, and the reconstruction of the experimental track charts. This volume contains a detailed report of the environmental measurements applicable to the acoustic experiments conducted during station 1, where five propagation loss runs were completed. Figure 1 shows the track of the source ship during these experiments. Source ship speed was 3 knots for runs 1-4 and 6 knots for run 5.

The detailed environmental data for each propagation loss run are summarized in the form of charts, plots, and tables in the appendices. Each appendix presents the same kind of data in the same sequence for all propagation loss runs. Additions and omissions are made as appropriate for the run described. Thus the first appendix figure (i.e., A-1, B-1, etc.) is a chart showing the locations of source and receiver ships, selected propagation paths, and wind velocity. The second figure (A-2, B-2, etc.) is a chart showing the locations of XBT and thermistor chain measurements used to determine the distribution of sound speed present during the acoustic experiments and the identification of the ship making the measurement. The balance of the figures and tables in the appendices are organized as follows:

Figure 3. Plot of selected sound-speed profiles from the surface to 400 m taken along the track of the source ship.* These are derived from the XBT and thermistor chain profiles whose locations are shown in Fig. 2. These profiles are used to identify any unusual changes in the horizontal distribution of sound speed particularly with regard to vertical profile shape. These plots show sound speed versus depth with the 1503-m/sec isospeed abscissa being located at the proper distance along the source ship track. The area containing sound speeds higher than 1503 m/sec is shaded. If a sound-speed profile boundary is crossed, the transition sound-speed profile shapes are shaded darker. The number is the time in local standard time.

Figure 4. Plot of thermistor chain temperature measurements at 10 selected depths about 25 m apart from the surface to 242 m except for run 5, a 6-knot tow, where the maximum depth was 221 m. Abscissas showing time, distance along source track, and acoustic range are also included. These plots are used to reveal any important horizontal temperature changes present during the acoustic experiments that might influence the experimental measurements.

Figure 5. Plot of thermistor chain temperature measurements at the source depth or at two depths, 6 m apart, bracketing the source depth. Format and purpose of the plots are the same as for Fig. 4.

In this paper only computed sound speeds are reported. The computed sound speeds are obtained from Anderson's sound-speed equation (Naval Undersea Research and Development Center, NUC TP 243, Sound Speed in Seawater as a Function of Realistic Temperature-Salinity-Pressure Domains, *by E. R. Anderson, August 1971). Discussions of sound-speed distributions present during the propagation loss measurements are based on the computed sound speeds.*

Figure 6. Plot of sound-speed profiles derived from XBT and thermistor chain measurements. These profiles were made at identically the same time and are used to give a limited evaluation of the spatial change in profile shape present during the propagation loss runs. The plot format is the same as that used in Fig. 3.

The following figures are included for all runs except run 1:

Figure 7. Plot of Waverider buoy measurements showing the standard deviation of 3-min averages of the measurements. The point is plotted at the beginning of the 3-min averaging interval. The dashed horizontal line is the standard deviation of the average of all measurements made during the propagation loss run. At the right is a histogram of the standard deviations.

Figure 8. Ogive of the standard deviation of the 3-min averages presented in Fig. 7.

Figure 9. Plot of standard deviation of the measurements as a function of wave period from 1.25 sec to 16.7 sec. The vertical bars are the 90-percent confidence limits for standard deviations of 1 cm and 10 cm.

The following figures are included for run 4 and Fig. 11 for run 3:

Figure 10. Expanded sound-speed profile plots derived from thermistor chain measurements. These are used to accurately establish position of boundaries.

Figure 11. Plot of thermistor chain measurements for 10 selected depths, about 6 m apart, to delineate the nature of the horizontal temperature change in the vicinity of the boundary crossings.

The following tables are also included in the appendices:

Table 1. Tabulated values of temperature as a function of standard hydrographic depths and time of day for all XBT and thermistor chain measurements used in the sound-speed distribution analysis. Also tabulated are the isothermal layer depth (ILD), temperature (T) of the ILD, and surface layer depth (SLD).

Table 2. Tabulated values of sound speed as a function of standard hydrographic depths to 400 m for all converted XBT and thermistor chain temperature measurements used in the analysis. Also tabulated are the surface channel depth (SC), depressed channel depths (DC), refractive channel depth (RC), and depths of the maxima below surface channels and depressed channels (MAX).

Table 3. Tabulated values of average sound speed at standard depths from the surface to 1500 m. Also included are the number of observations and the depths of the surface channel, depressed channels, refractive channels, sound-speed maxima, and the axis of minimum sound speed. The average values are obtained from thermistor chain measurements (0-250 m), XBT, hydrographic cast, and STD/SV measurements (300-400 m), and hydrographic casts and STD/SV measurements (500-1500 m). For runs 3 and 4, two sound-speed profiles, delineated by the sound-speed profile boundary are tabulated. These are the recommended sound speeds to be used from the surface to 1500 m.

Table 4. Tabulated values of the average temperature for each thermistor chain sensor. Shown are the sensor depth, the number of temperature measurements, the

minimum and maximum recorded temperature, and the mean and standard deviation.

Table 5. Tabulated sea-surface roughness data used to prepare Fig. 7.

Table 6. Tabulated sea-surface roughness data used to prepare Fig. 8.

DISCUSSION

RUN 1 – 10 February 1972 0251-0647 LST

The plots of the individual sound-speed profiles shown in Figs. A-3 and A-6 suggest that the experiment was conducted in a single sound-speed-profile water volume. The individual profiles show surface channels at depths varying from 6 to 50 m, small depressed channels at depths varying from 20 to 50 m, and a refractive channel at 200 m.

Figure 2 is a plot of the average sound speeds listed in Table A-3. The details of the average sound-speed distribution in the upper 200 m are shown in Fig. 3. The source and receivers depths are also shown on Fig. 3. The average sound-speed profile is characterized by a 20-m surface channel and a 70-m refractive channel with the minimum sound speed at 200 m. The small depressed channels, shown in individual profiles, are not present in the average profile. However, the average thermistor chain data in Table A-4 shows a depressed channel with axis at about 50 m.

During run 1 the *Lee* reported light airs, 1-ft waves, and 3-ft swell, while the *DeSteiguer* reported 4- to 5-knot winds, ripples, and 2-ft swell. No Waverider buoy measurements were obtained during this run.

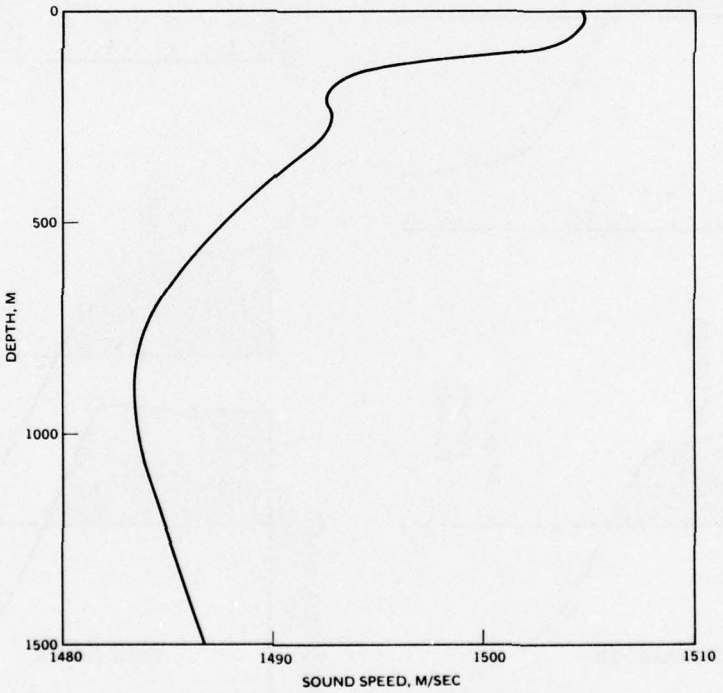

Figure 2. Station 1, run 1. Average sound-speed profile.

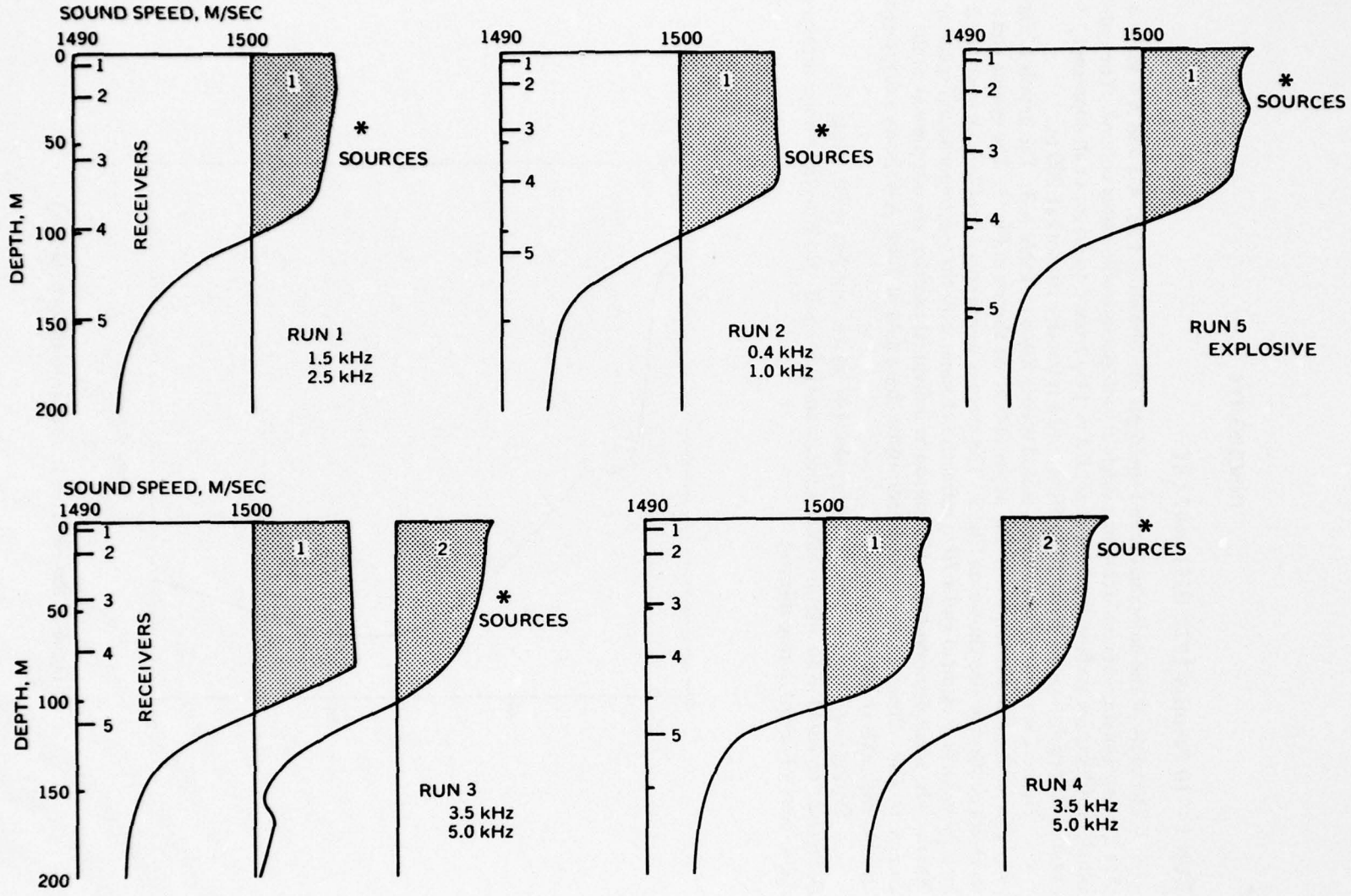

Figure 3. Average sound-speed profile summary for acoustic station 1.

RUN 2 – 11 February 1972 0052-0515 LST

The plots of the individual sound-speed profiles, Figures B-3 and B-6, show surface channels from 10 m to 80 m, small depressed channels from 20 m to 50 m, and refractive channels from 190 m to 250 m. No coherent sound-speed profile boundaries are indicated.

Figure 4 is a plot of the average sound speeds listed in Table B-3. The details of the average sound-speed distribution in the upper 200 m are shown in Fig. 3. The average sound-speed profile contains a 68-m surface channel and an isospeed layer from 200 m to 300 m. The small depressed channels and the refractive channels, shown in the individual profiles, are not preserved in the average profile. As shown in Fig. B-1, the acoustic propagation paths are not in the same plane as the track of the source ship.

During this run the *Lee* reported 10-knot winds, 2-ft waves, and 5-ft swell, while the *DeSteiguer* reported 12-knot winds, 1-ft waves, and 3- to 4-ft swell. Waverider buoy measurements were obtained for the complete run. Table B-5 and Figs. B-7 and B-8 present the standard deviations of the Waverider buoy measurements for 3-min averages. The standard deviation of the 3-min averages varied from 31 to 68 cm with 68.6 percent of the standard deviations between 35 and 50 cm. To detect any change in sea-surface roughness during the propagation loss run, the Waverider buoy record was divided into four 63-min records. A spectrum analysis was made of each of these subsets. A bandwidth of 0.0056 Hz (21 harmonics) was used, with the 90-percent confidence limits being 0.67 to 1.36 for 42 degrees of freedom. The individual spectra did not indicate a change with time during the experiment. Table B-6 contains a tabulation of the ensemble average of the four 63-min spectra. These data are plotted in Fig. B-9. Two trains of swell centered at about 11.0 sec and 15.7 sec are present. These wave periods are associated with the 3- to 5-ft swell reported by the *Lee* and *DeSteiguer*. Also present are 1.5-sec to 2.5-sec wind waves. These wind waves are the result of the local 10 to 12-knot winds reported by the *Lee* and *DeSteiguer*.

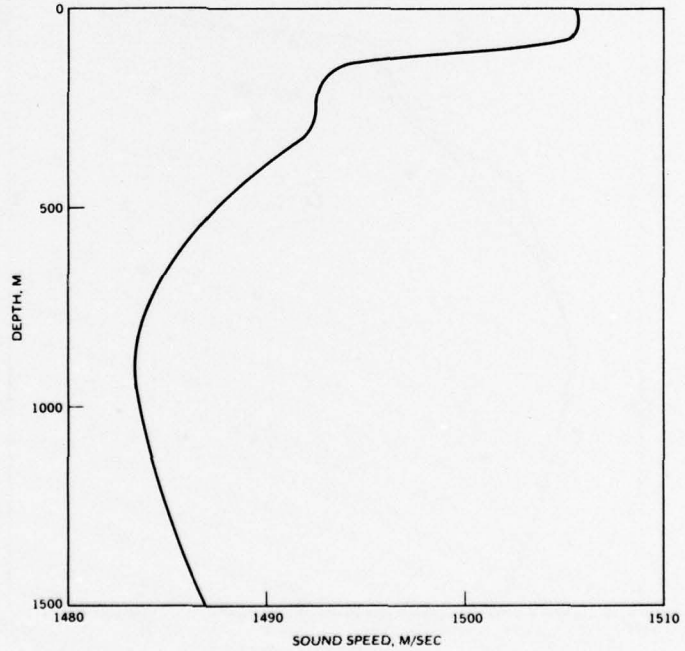

Figure 4. Station 1, run 2. Average sound-speed profile.

RUN 3 – 11 February 1972 0721-1330 LST

An examination of the individual sound-speed profiles plotted in Fig. C-3 suggests a sound-speed profile boundary was crossed at about 1130 LST at an acoustic range from the receivers of 27.5 kyd. From 0721 to 1130 LST both source and receivers were in a water volume characterized by a 79-m surface channel. From 1130 to 1330 LST, the end of the run, the source was in a water volume characterized by a negative sound-speed gradient starting at the surface. The thermistor chain temperature measurements made from the surface to 73 m (plotted in Figs. C-4 and C-11) show a change in the nature of the temperature variation after 1130 LST. Figure C-5 shows that this change also occurred at the source depths.

Figure 5 is a plot of the two average sound-speed profiles tabulated in Table C-3. The details of the average sound-speed profiles in the upper 200 m are shown in Fig. 3. Profile 1 is characterized by a 79-m surface channel, while profile 2 is characterized by a negative sound-speed gradient starting from the surface and a small 20-m refractive channel centered at 156 m. As shown in Fig. C-1 the propagation paths coincide quite closely with the track of the source ship.

During this run both the *Lee* and *DeSteiguer* reported 4- to 8-knot winds, 1-ft waves, and 3-ft swell. Waverider buoy measurements were obtained for the complete run. Table C-5 and Figs. C-7 and C-8 present the standard deviation of the Waverider buoy measurements for 3-min averages. The standard deviation of the 3-min averages varied from 26 to 76 cm, with 63.9 percent between 35 and 55 cm. To detect any change in sea-surface roughness during the experiment the original record was divided into six 60-min records and a spectrum analysis was made of each of these subsets. In preparing these spectra, a bandwidth of 0.0058 Hz (21 harmonics) was used. For 42 degrees of freedom the 90-percent confidence

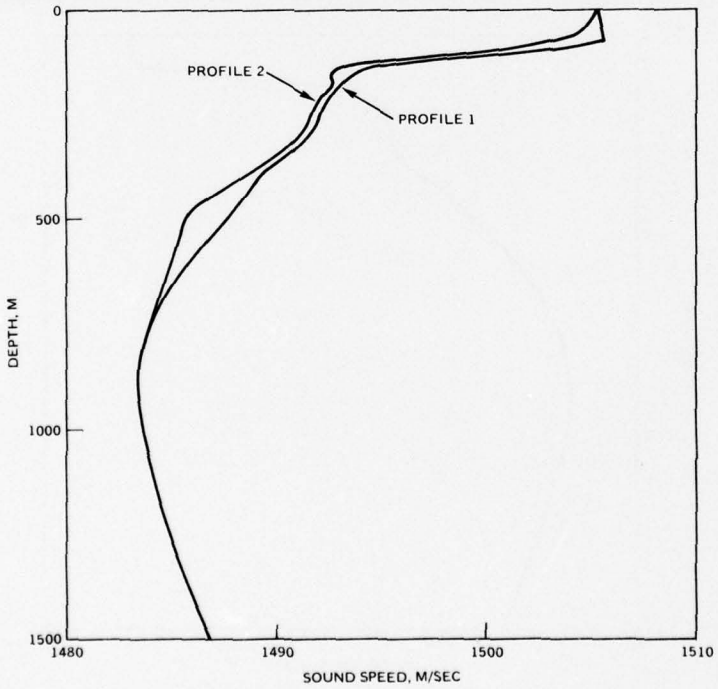

Figure 5. Station 1, run 3. Average sound-speed profiles.

limits are 0.68 to 1.36. The 60-min spectra did not indicate any significant change with time. Table C-6 contains a tabulation of the ensemble average of the six 60-min spectra. These data are plotted in Fig. C-9. This analysis shows 1.5-sec to 3.5-sec waves generated by the local 4- to 8-knot winds and swell centered at a 9.5-sec wave period. The 9.5-sec wave period is associated with the 3-ft swell reported by the *Lee* and *DeSteiguer*.

RUN 4 – 11 February 1972 1438-2119 LST

During this run the source ship did not maintain a constant course heading, but made several small course changes, with a major change of 55 degrees executed at 1910 LST. This resulted in the source ship crisscrossing the propagation paths. This run crossed the same sound-speed profile boundary crossed during run 3 at 1635 LST at an acoustic range of 30.0 kyd. Thus prior to 1635 LST, the source ship was in the profile 2 volume and the receiving ship was in the profile 1 volume. For the remainder of the run both ships were in the same sound-speed profile volume.

Figure 6 is a plot of the two average sound-speed profiles tabulated in Table D-3. The details of the average sound-speed profile in the upper 200 m are shown in Fig. 3. The two profiles differ from the surface to 800 m. Profile 2 exhibited negative sound-speed gradients from the surface down to the 900-m deep-channel axis, with no surface, depressed, or refractive channels present. Profile 1 contained a 12-m depressed channel centered at 20 m and 70-m refractive channel centered at 200 m. The 79-m surface channel present in the profile 1 volume during run 3 was eliminated by daytime heating of the upper layers and was replaced by the depressed channel. The transient surface, depressed, and refractive

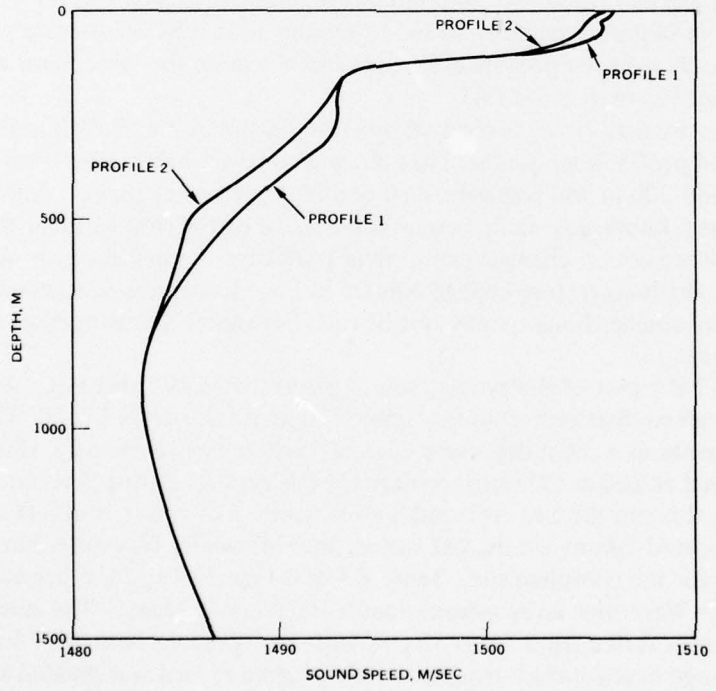

Figure 6. Station 1, run 4. Average sound-speed profiles.

channels present in the individual profiles were not preserved in the average profiles. Figures D-4 and D-11 indicate a large variability in temperature from 73 m to 147 m all along the source track. Above and below these depths the spatial variability is small.

During this run the *Lee* reported 8-knot winds increasing to 15 knots during the run, 2-ft waves, and 4-ft swell, while the *DeSteiguer* reported 10- to 12-knot winds, 1-ft waves, and 3- to 5-ft swell. Waverider buoy measurements were obtained for the complete run. Table D-5 and Figs. D-7 and D-8 present the standard deviation of the measurements for 3-min averages. The standard deviation of the 3-min averages varied from 36 to 83 cm, with 60.2 percent between 40 and 60 cm. To detect any change in sea-surface roughness during the acoustic run, the Waverider buoy record was divided into seven 55-min records. A spectrum analysis was made of each of these subsets. In preparing these spectra, a bandwidth of 0.0057 Hz (19 harmonics) was used. The 90-percent confidence limits are 0.67 to 1.39 (38 degrees of freedom). The individual spectra did indicate a change with time. Figure D-9a presents the spectrum from 1442 LST to 1537 LST, the first 55 min of the run; Fig. D-9b presents the spectrum from 1538 LST to 1825 LST; and Fig. D-9c presents the spectrum from 1826 LST to 2113 LST. At the beginning of the run, 1.7-sec wind waves were present, with the period increasing to 3.2 sec as the run progressed. This change is associated with the increasing speed of the local winds reported by the *Lee*. During the beginning of the run, 9.7-sec swell was present. This swell decayed during the run, although it was still detectable at the end of the run. Figure D-9c shows 14.4-sec swell moving into the area during the last 2 to 3 hours of the run. Table D-6 lists the data plotted in Fig. D-9.

RUN 5 – 12 February 1972 1125-1400 LST

During this run the source ship did not maintain a constant heading. Course changes of 71, 37, and 41 deg were made at 1230, 1245, and 1310 LST, respectively. As a result of these course changes the propagation paths did not lie in the same plans as the track of the source ship prior to about 1300 LST.

An examination of the individual profiles plotted in Fig. E-3 did not show any coherent sound-speed profile boundaries. They show a consistent refractive channel centered between 125 and 200 m and transient surface and depressed channels. Since the tow speed for this run was 6 knots, any changes in relative speed of the ship through the water associated with the three course changes would tend to change the depth of the thermistor chain sensors. Thus, the temperature changes shown in Figs. E-4 and E-5, especially during and shortly after the course changes, may not be real, but rather due to vertical movements of the thermistor chain.

Figure 7 is a plot of the average sound speeds listed in Table E-3. The details of the average sound-speed distribution in the upper 200 m are shown in Fig. 3. The average sound-speed profile contains a 20-m depressed channel centered at 18 m and a 100-m refractive channel centered at 200 m. No surface channel was present during this run.

During this run the *Lee* reported 5-knot winds, 1-ft waves, and 3-ft swell, while the *DeSteiguer* reported 7-knot winds, 1-ft waves, and 4-ft swell. Waverider buoy measurements were obtained for the complete run. Table E-5 and Figs. E-7 and E-8 present the standard deviation of the Waverider buoy measurements for 3-min averages. The standard deviation of the 3-min averages varied from 31 to 58 cm, with 56.9 percent between 35 and 55 cm. To detect any change in sea-surface roughness, the original record was divided into three 49-min records and a spectrum analysis was made of each of these subsets. In preparing these spectra, a bandwidth of 0.0057 Hz (17 harmonics) was used. The 90-percent confidence limits are

0.65 to 1.40 (34 degrees of freedom). The 49-min spectra did not indicate any significant change with time. Consequently, they were combined into a single-spectrum. Table E-6 lists the ensemble average of the three 49-min spectra. These data are plotted in Fig. E-9. This analysis shows 4.2-sec wind waves and a band of 12.2- to 15.4-sec swell.

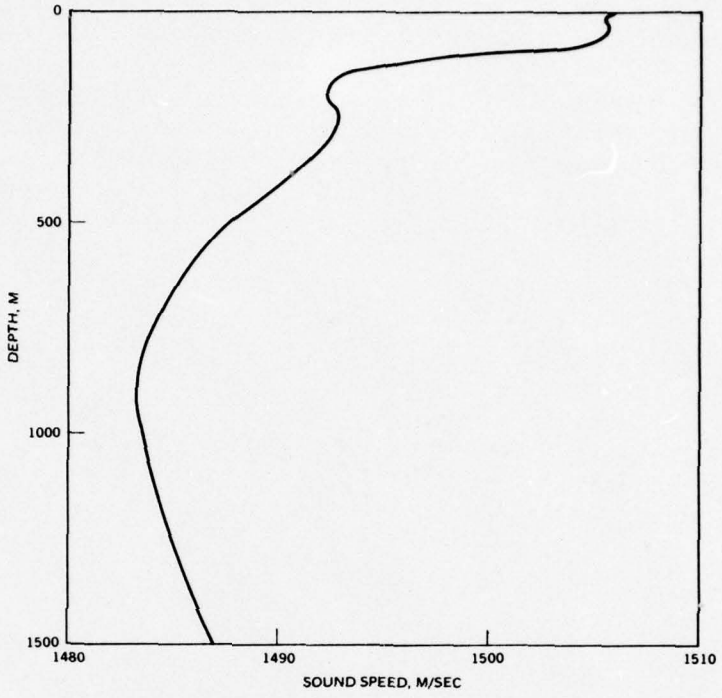

Figure 7. Station 1, run 5. Average sound-speed profile.

SUMMARY

Four CW and one explosive propagation loss runs were made at station 1 over a 59 hr 11 min period from 0251 LST 10 February to 1400 LST 12 February. Oceanographic measurements made during these runs showed a northeast-southwest-oriented sound-speed profile boundary present in the southeast portion of the experimental area. This boundary was crossed during runs 3 and 4 with runs 1, 2, and 5 made in a water mass containing a single sound-speed profile. The profile 1 water mass was characterized by an 80-m surface layer containing a surface sound channel during runs 1, 2, and 3 and a depressed channel during runs 4 and 5. The profile 2 water mass contained a negative sound-speed gradient from the surface to 200 m.

Mild weather prevailed during the time the propagation loss measurements were made. Wind speeds varying from near calm to 12 knots, produced 1- to 2-ft wind waves accompanied by 3- to 5-ft swell. Spectral analysis of the sea-surface roughness measurements made by the Waverider buoy during runs 2, 3, 4, and 5 showed most of the wave energy in the 10- to 16-sec wave period band of swell, with lesser amounts of energy in the 1.5- to 3.5-sec wave period band of wind waves. During runs 2, 3, and 5 there was no change in the spectra during the run. However, during run 4 there was a change in the spectra with time. At the beginning of the run 1.7-sec wind waves were present, with the period increasing to 3.2 sec as the run progressed. During the beginning of the run, a 9.7-sec swell was present. This swell decayed during the run, although it was still detectable when the run terminated. During the last 2 to 3 hours of the run, a 14.4-sec swell began to move into the area.

APPENDIX A

STATION 1 RUN 1

DETAILED ENVIRONMENTAL DATA SUMMARY

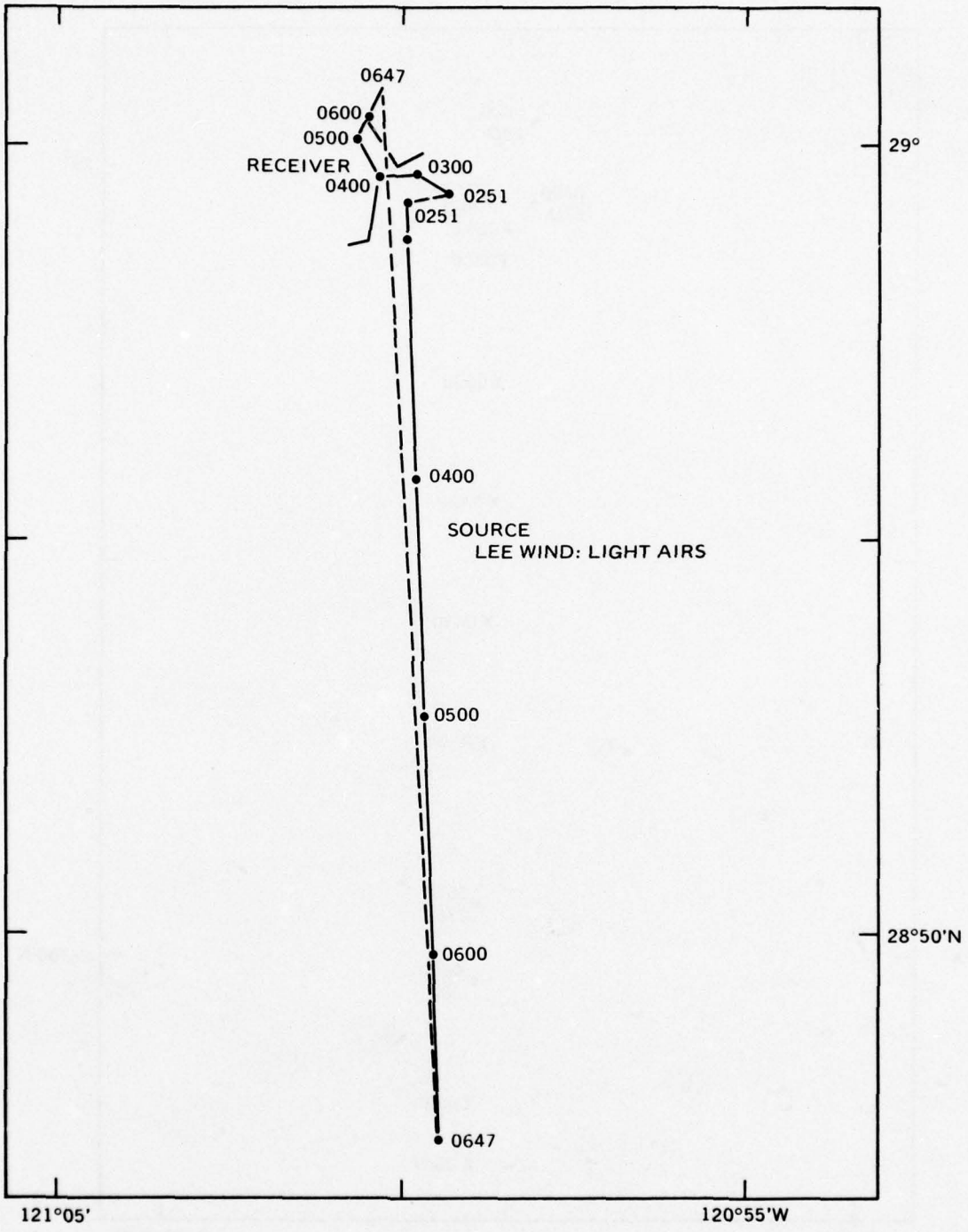

Figure A-1. Station 1, run 1. Location of source and receiver ships, 0251 and 0647 LST propagation paths (---) and wind velocity (5-knot east wind).

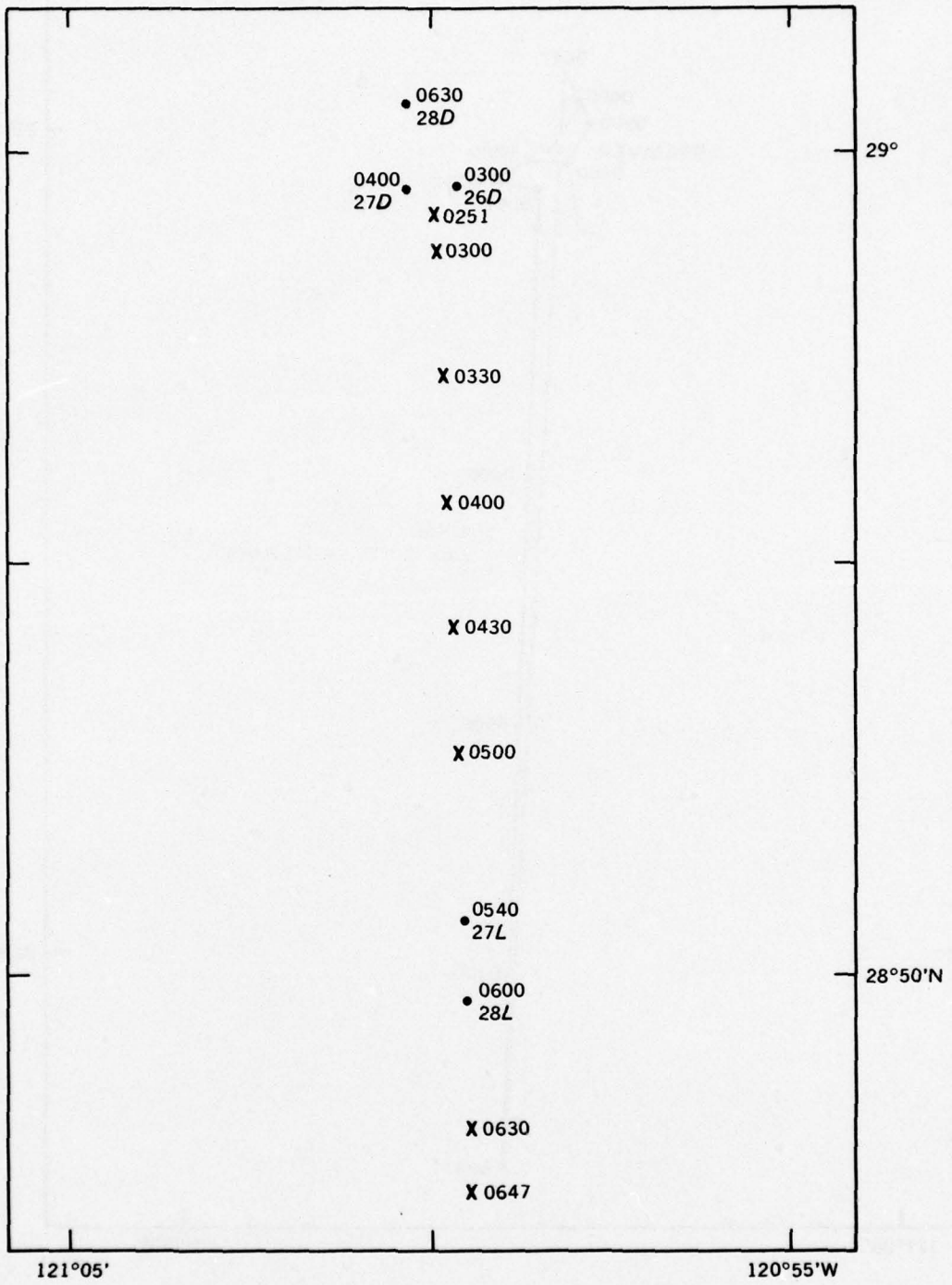

Figure A-2. Station 1, run 1. Location of XBT (•) and thermistor chain (X) measurements. The letter following the XBT number denotes the ship which took the measurement (*L:Lee, D:DeSteiguer*). The times shown are LST.

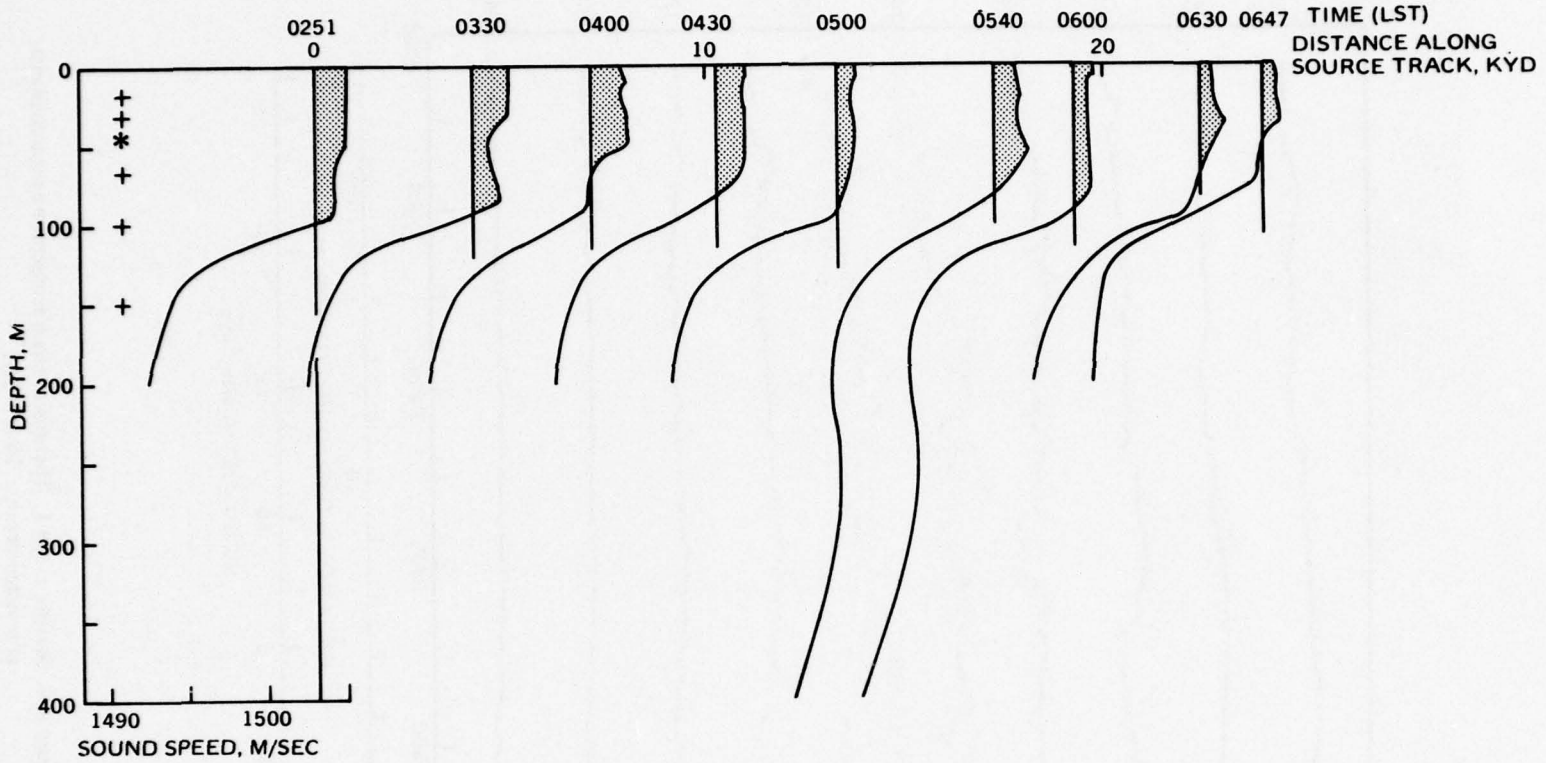

Figure A-3. Station 1, run 1. Sound speed profiles along track of source ship derived from XBT and thermistor chain data. Source depth (*), receiver depth (+).

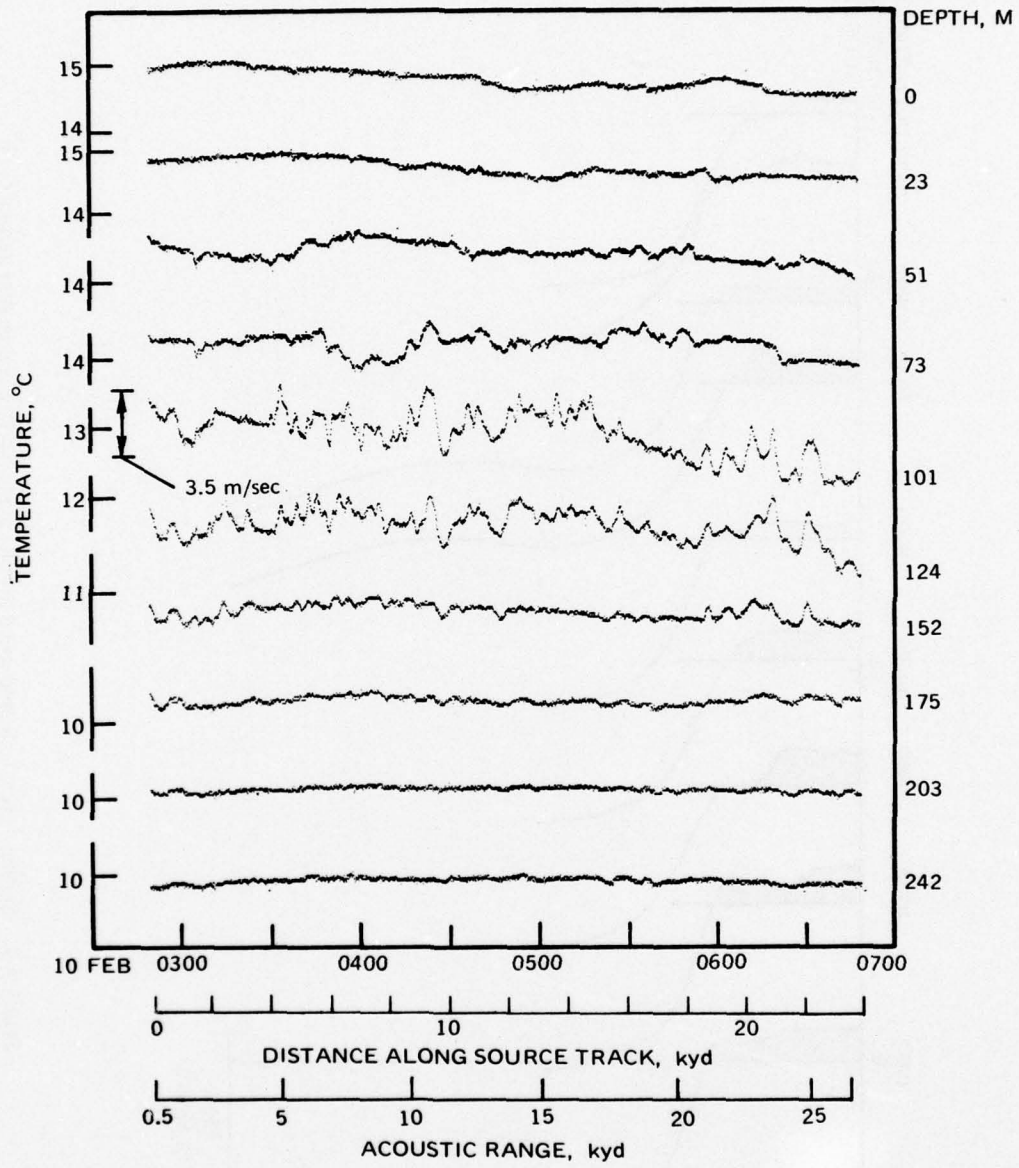

Figure A-4. Station 1, run 1. Thermistor chain temperature measurements at selected depths. Time is LST.

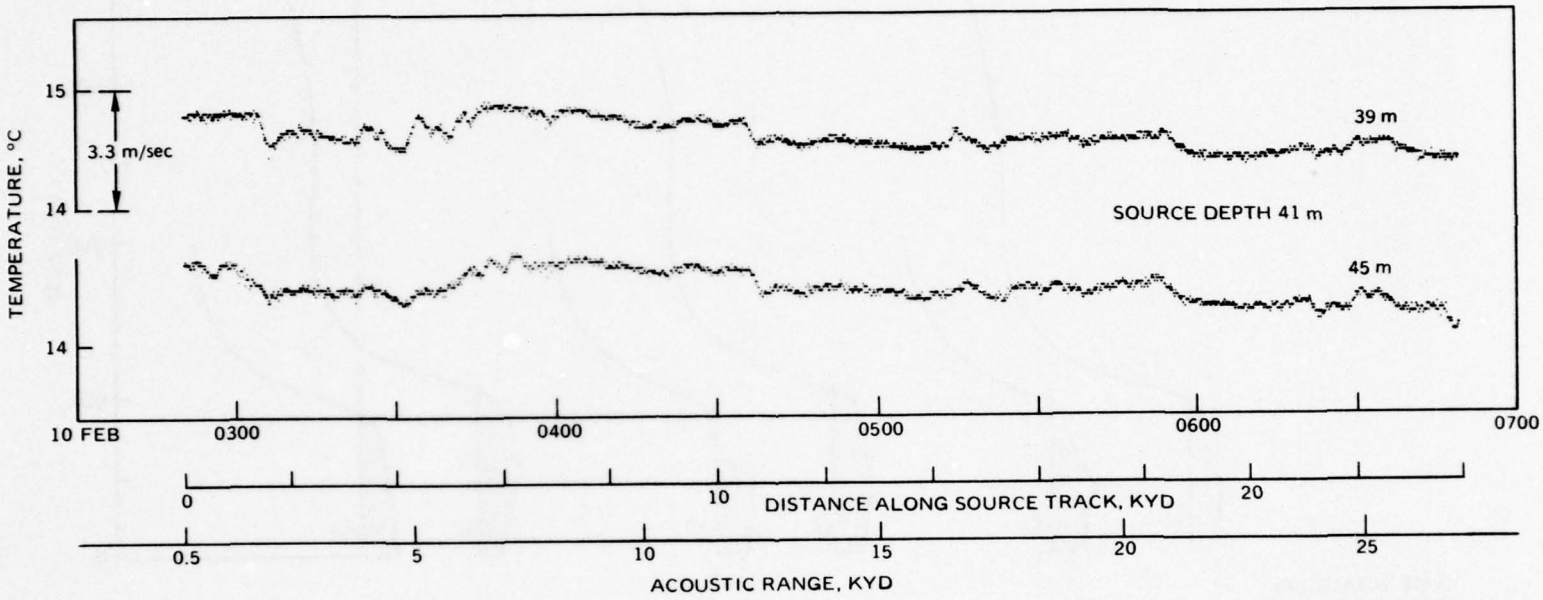

Figure A-5. Station 1, run 1. Temperatures above and below source. Time is LST.

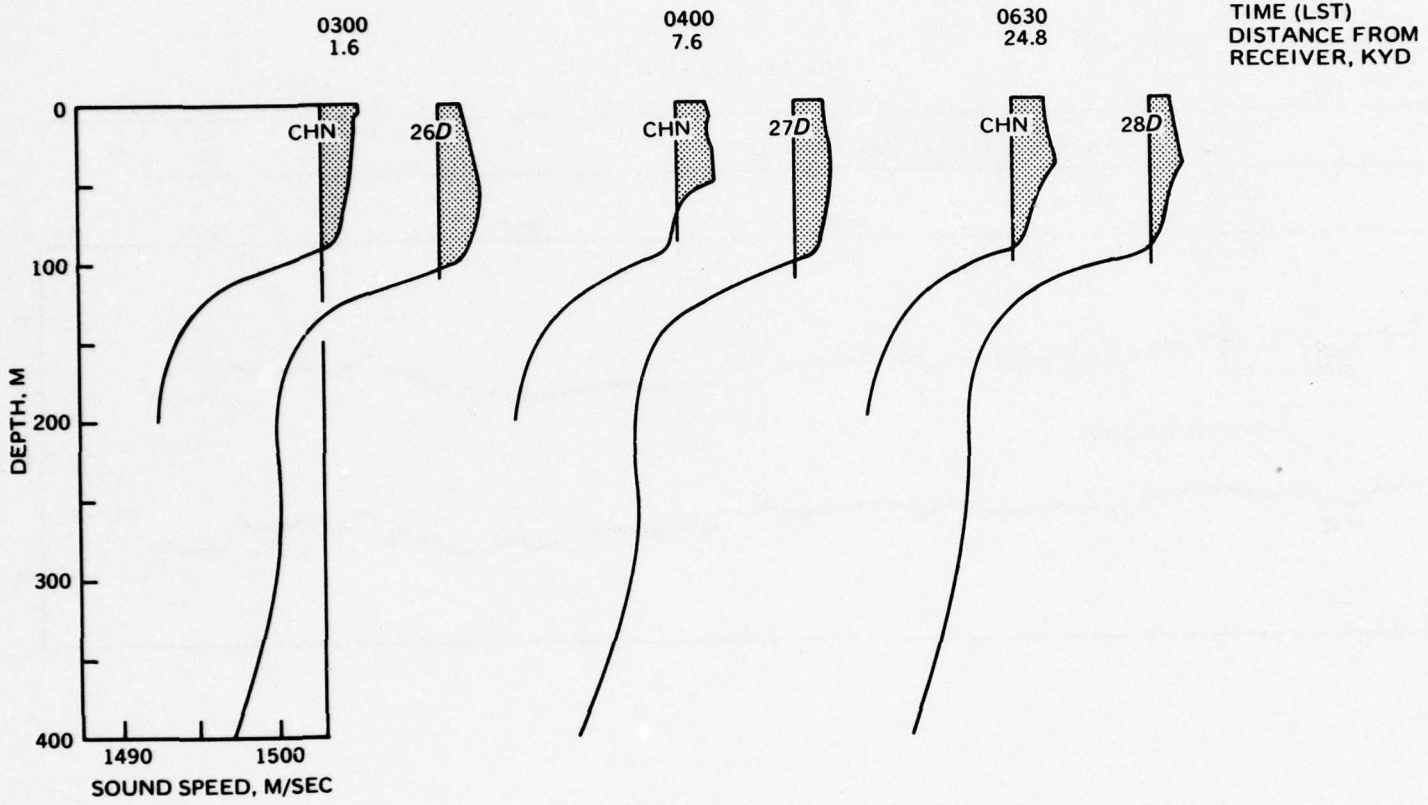

Figure A-6. Station 1, run 1. Spatial change in sound-speed profile.

Table A-1. Temperature Profiles (°C),
Station 1 Run 1 (10 February 1972 0251-0647 LST).

XBT MEASUREMENTS

Depth, m	27L 0540	28L 0600	26D 0300	27D 0400	28D 0630
0	14.7	14.7	14.7	14.8	14.7
10	14.7	14.5	14.7	14.8	14.7
20	14.7	14.5	14.7	14.8	14.7
30	14.6	14.4	14.7	14.8	14.7
50	14.6	14.3	14.8	14.7	14.5
75	14.2	14.3	14.6	14.5	14.2
100	12.9	13.5	14.1	13.9	13.3
125	11.5	11.5	11.8	12.0	11.3
150	10.8	10.7	10.9	10.9	10.5
200	10.2	10.2	10.2	10.2	9.8
250	10.0	10.0	9.9	9.9	9.5
300	9.6	9.5	9.5	9.5	9.0
400	8.4	8.2	8.3	8.1	7.8
ILD	20	9	50	30	40
T	14.7	14.7	14.7	14.8	14.7
SLD	57	75	101	100	93

THERMISTOR CHAIN MEASUREMENTS

Depth, m	0251	0300	0330	0400	0430	0500	0630	0647
0	14.9	15.0	15.0	14.9	14.8	14.7	14.5	14.5
10	14.8	14.9	15.0	14.9	14.8	14.6	14.5	14.5
20	14.8	14.9	14.9	14.8	14.7	14.5	14.5	14.5
30	14.7	14.7	14.8	14.8	14.7	14.5	14.5	14.5
50	14.7	14.5	14.4	14.7	14.5	14.4	14.3	14.0
75	14.3	14.3	14.4	13.9	14.2	14.2	13.9	13.8
100	13.5	13.2	13.2	13.2	12.8	13.3	12.9	12.2
125	11.6	11.4	11.4	11.7	11.3	11.5	11.6	10.9
150	10.8	10.8	10.8	10.9	10.8	10.8	10.8	10.5
200	10.1	10.1	10.1	10.2	10.2	10.2	10.2	10.1
ILD	6	6	11	11	6	11	39	34
T	14.9	15.0	15.0	14.9	14.8	14.6	14.5	14.5
SLD	96	85	79	96	68	96	96	73

Table A-2. Computed Sound-Speed Profiles (m/sec), Station 1 Run 1 (10 February 1972 0251–0457 LST).

XBT MEASUREMENTS

Depth, m	27L 0540	28L 0600	26D 0300	27D 0400	28D 0630
0	1504.3	1504.3	1504.3	1504.7	1504.3
10	04.5	03.9	04.5	04.8	04.5
20	04.7	04.0	04.7	05.0	04.7
30	04.5	03.9	04.8	05.2	04.8
50	04.8	03.9	05.5	05.2	04.5
75	03.9	04.2	05.2	04.9	03.9
100	00.0	02.1	04.1	03.4	01.4
125	1495.7	1495.7	1496.7	1497.4	1495.0
150	93.7	93.4	94.1	94.1	92.7
200	92.6	92.6	92.6	92.6	91.2
250	93.1	93.1	92.8	92.8	91.2
300	92.8	92.4	92.4	92.4	90.5
400	90.1	89.3	89.7	88.9	89.7
SC	20	9	50	50	40
DC	30	30			
MAX	57	75			
RC	200	200	200	200	
MAX	265	250	250	250	

THERMISTOR CHAIN MEASUREMENTS

Depth, m	0251	0300	0330	0400	0430	0500	0630	0647
0	1505.0	1505.3	1505.2	1504.8	1504.7	1504.2	1503.7	1503.7
10	04.9	05.1	05.3	05.1	04.7	04.1	03.9	03.9
20	04.9	05.0	05.2	04.9	04.6	04.0	03.9	03.9
30	04.9	05.0	05.2	05.2	04.8	04.1	04.2	04.1
50	05.0	04.6	04.0	05.3	04.7	04.2	03.9	03.0
75	04.3	04.2	04.4	02.8	03.8	03.7	02.9	02.4
100	02.1	00.9	01.1	01.0	1499.7	01.5	00.0	1497.7
125	1496.1	1495.2	1495.3	1496.4	95.1	1495.8	1495.8	93.4
150	93.8	93.7	93.8	94.1	93.6	93.6	93.9	92.6
200	92.4	92.4	92.4	92.6	92.7	92.5	92.4	92.1
SC	6	6	11	11	6	6	39	34
DC	20		50	20	20	20		
MAX	50		79	50	30	50		

Table A-3. Average Sound-Speed Profile (m/sec), Station 1 Run 1 (10 February 1972 0251-0647LST).

Depth, m	Number of Observations	Average Speed	Standard Deviation
0	1431	1504.51	0.52
10	1431	04.66	0.52
20	1431	04.66	0.46
30	1431	04.61	0.46
50	1431	04.29	0.49
75	1431	03.77	0.46
100	1431	00.33	1.22
125	1431	1495.80	0.86
150	1431	93.73	0.42
200	1431	92.41	0.15
250	1431	92.71	0.19
300	12	92.33	0.69
400	10	89.69	1.04
500	4	87.54	0.68
600	4	85.79	0.75
800	6	83.59	0.29
1000	5	83.54	0.19
1200	5	84.57	0.13
1500	5	86.66	0.09
20		1504.66	SC
200		1492.41	RC
250		1492.71	MAX
900		1483.40	AXIS

Table A-4. Average Thermistor Chain Temperatures
Station 1 Run 1 (number of measurements at each depth: 1431).

Depth, m	Temperature, °C			Standard Deviation
	Min	Max	Mean	
0	14.45	15.05	14.75	0.164
6	14.47	15.05	14.74	0.161
11	14.45	15.00	14.70	0.145
17	14.37	14.87	14.62	0.143
23	14.42	14.95	14.66	0.142
28	14.37	14.90	14.63	0.143
34	14.32	14.90	14.61	0.139
39	14.32	14.87	14.58	0.135
45	14.07	14.75	14.45	0.137
51	14.00	14.80	14.43	0.145
56	13.97	14.82	14.43	0.150
62	13.92	14.70	14.37	0.142
68	13.85	14.60	14.30	0.149
73	13.80	14.55	14.20	0.159
79	13.35	14.47	14.12	0.168
85	12.77	14.32	13.92	0.224
90	12.35	14.22	13.70	0.333
96	12.20	14.12	13.50	0.393
101	12.10	13.65	12.89	0.347
107	11.77	13.30	12.65	0.294
113	11.30	13.00	12.32	0.309
118	10.97	12.57	11.92	0.304
124	10.77	12.07	11.57	0.235
130	10.77	11.80	11.30	0.176
135	10.72	11.45	11.11	0.127
141	10.52	11.20	10.96	0.107
147	10.50	11.10	10.86	0.121
152	10.45	10.97	10.72	0.116
158	10.40	10.87	10.62	0.099
164	10.30	10.72	10.50	0.074
169	10.22	10.60	10.40	0.069
175	10.17	10.50	10.32	0.060
180	10.15	10.42	10.28	0.044
186	10.07	10.32	10.23	0.039
192	10.02	10.30	10.20	0.043
197	10.02	10.25	10.15	0.041
203	9.97	10.25	10.14	0.044
209	9.92	10.20	10.09	0.050
214	9.90	10.20	10.06	0.054
220	9.87	10.15	10.04	0.054
226	9.85	10.10	9.99	0.054
231	9.77	10.05	9.94	0.054
237	9.77	10.05	9.94	0.055
242	9.77	10.05	9.91	0.052

APPENDIX B

STATION 1 RUN 2

DETAILED ENVIRONMENTAL DATA SUMMARY

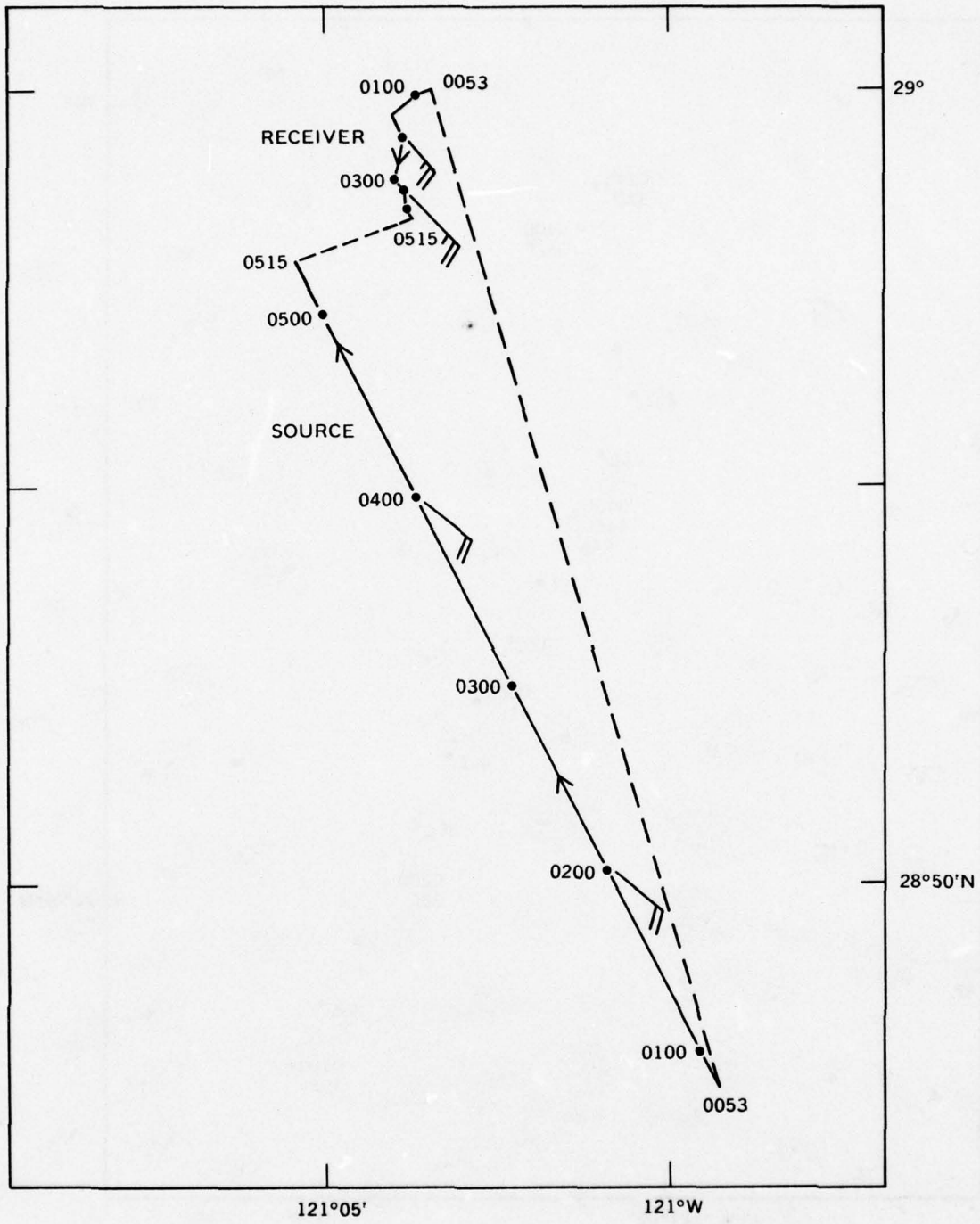

Figure B-1. Station 1, run 2. Location of source and receiver ships, 0053 and 0515 LST propagation paths (---), and wind velocity (10-knot east wind, 1 bar = 5 knots).

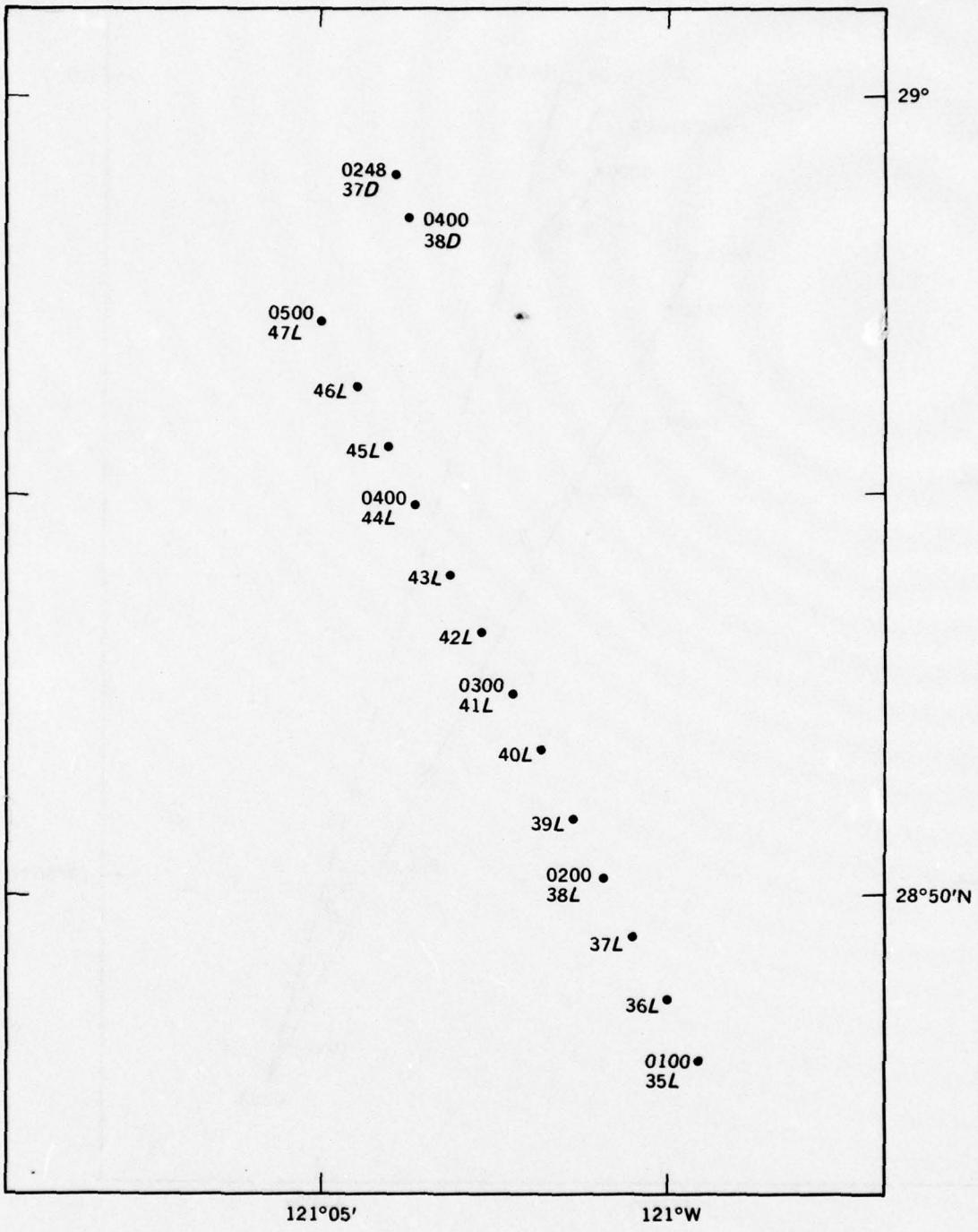

Figure B-2. Station 1, run 2. Location of XBT (·) measurements. The letter following the XBT number denotes the ship which took the measurement (*L:Lee, D:DeSteiguer*). The times shown are LST.

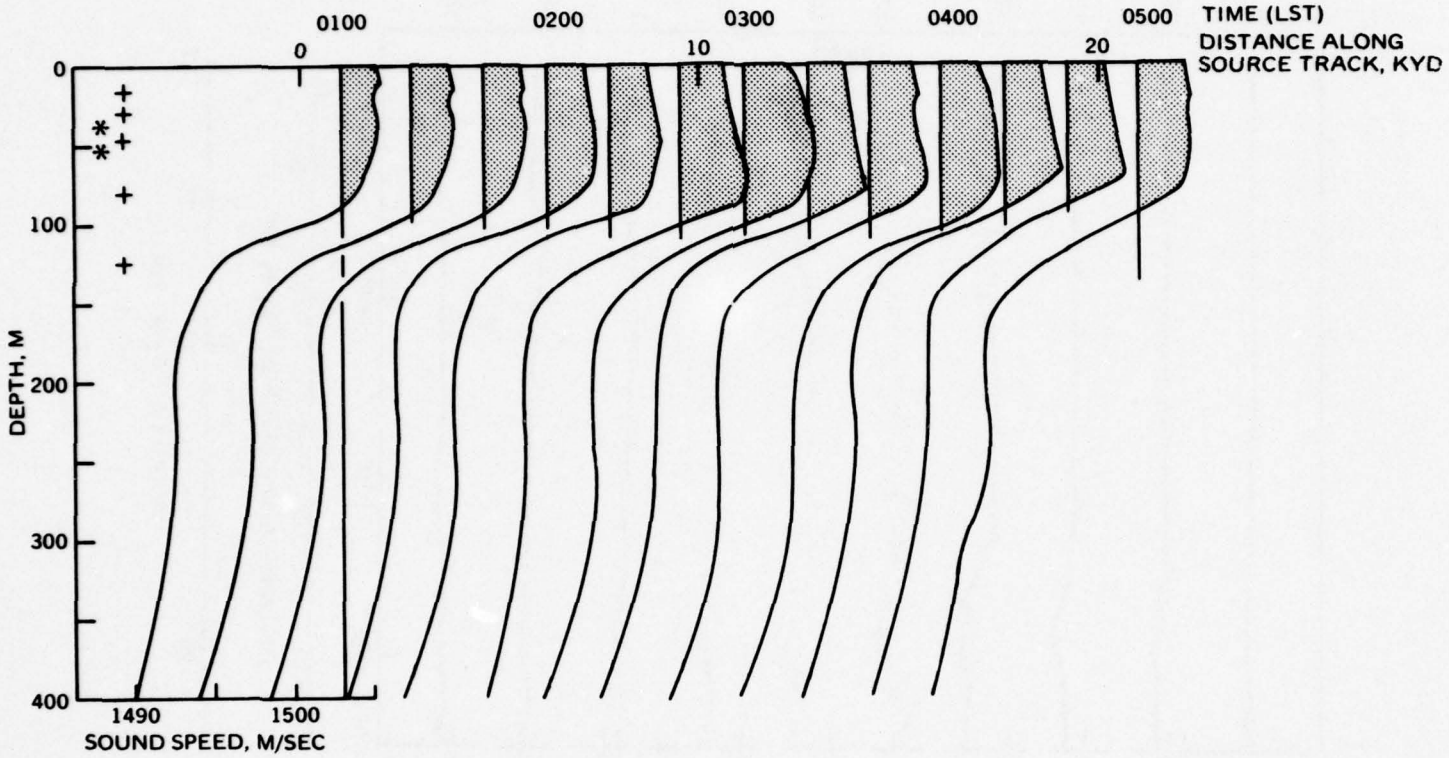

Figure B-3. Station 1, run 2. Sound-speed profiles along track of source ship derived from XBT data. Source depth (*), receiver depths (+).

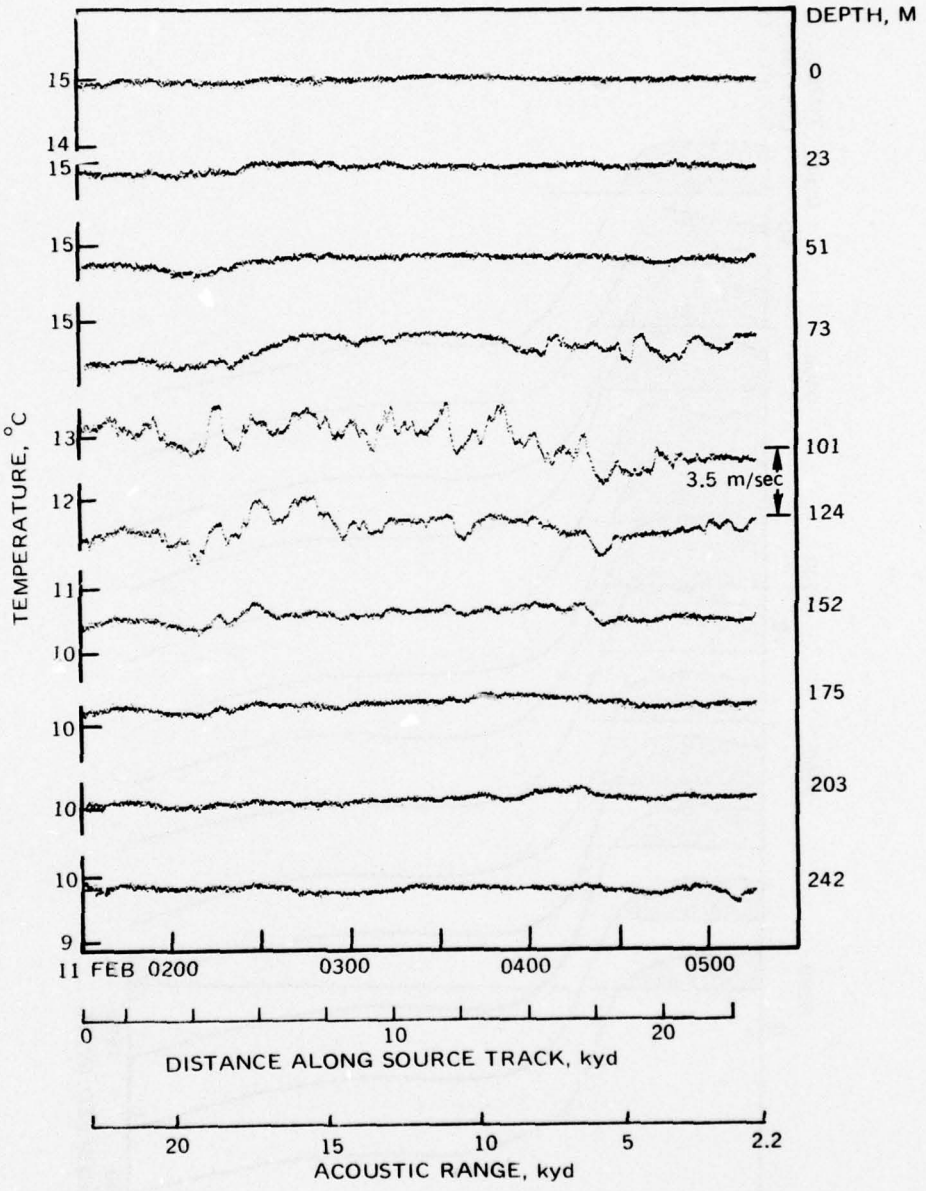

Figure B-4. Station 1, run 2. Thermistor chain temperature measurements at selected depths. Time is LST.

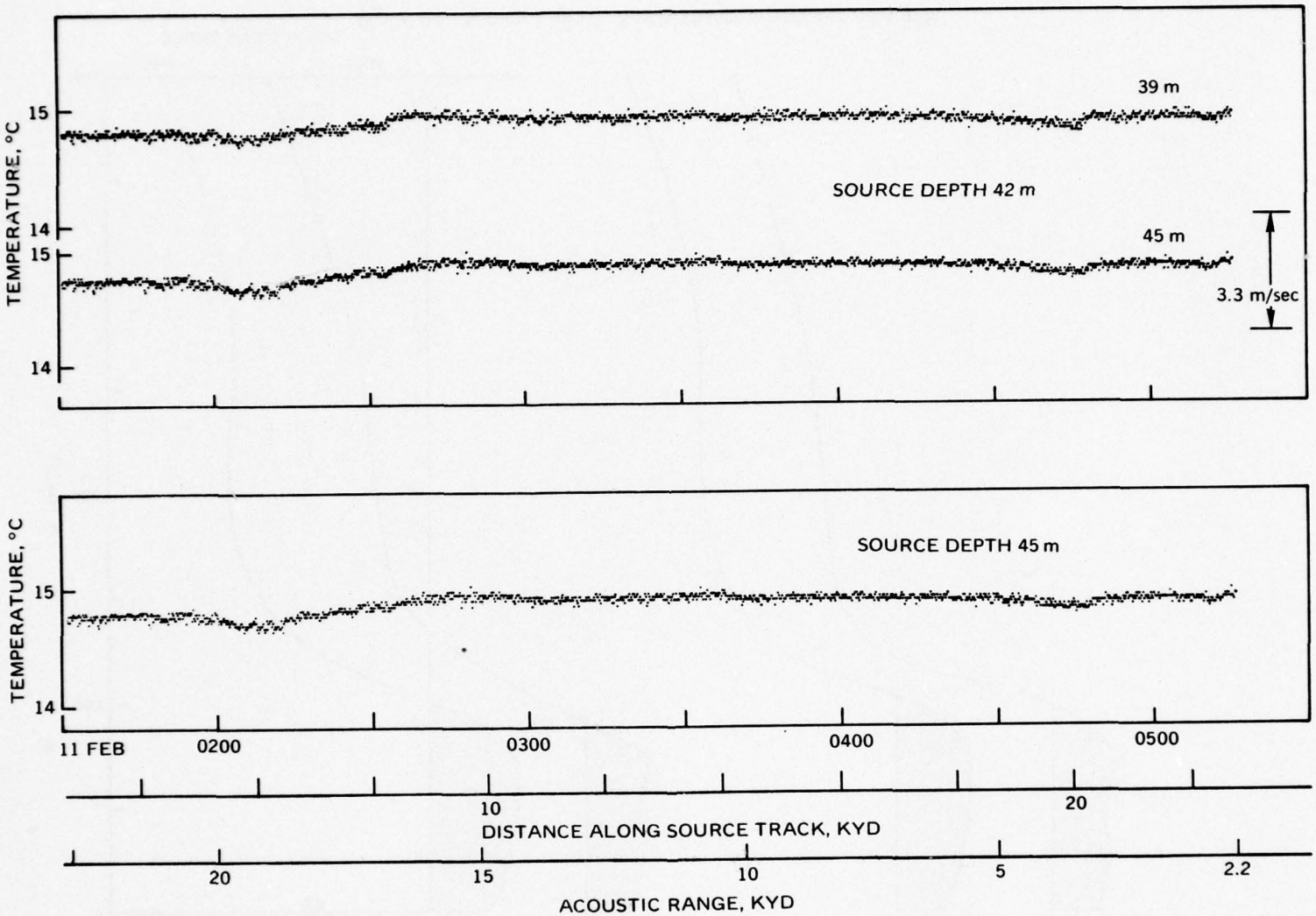

Figure B-5. Station 1, run 2. Temperatures at source depth. Time is LST.

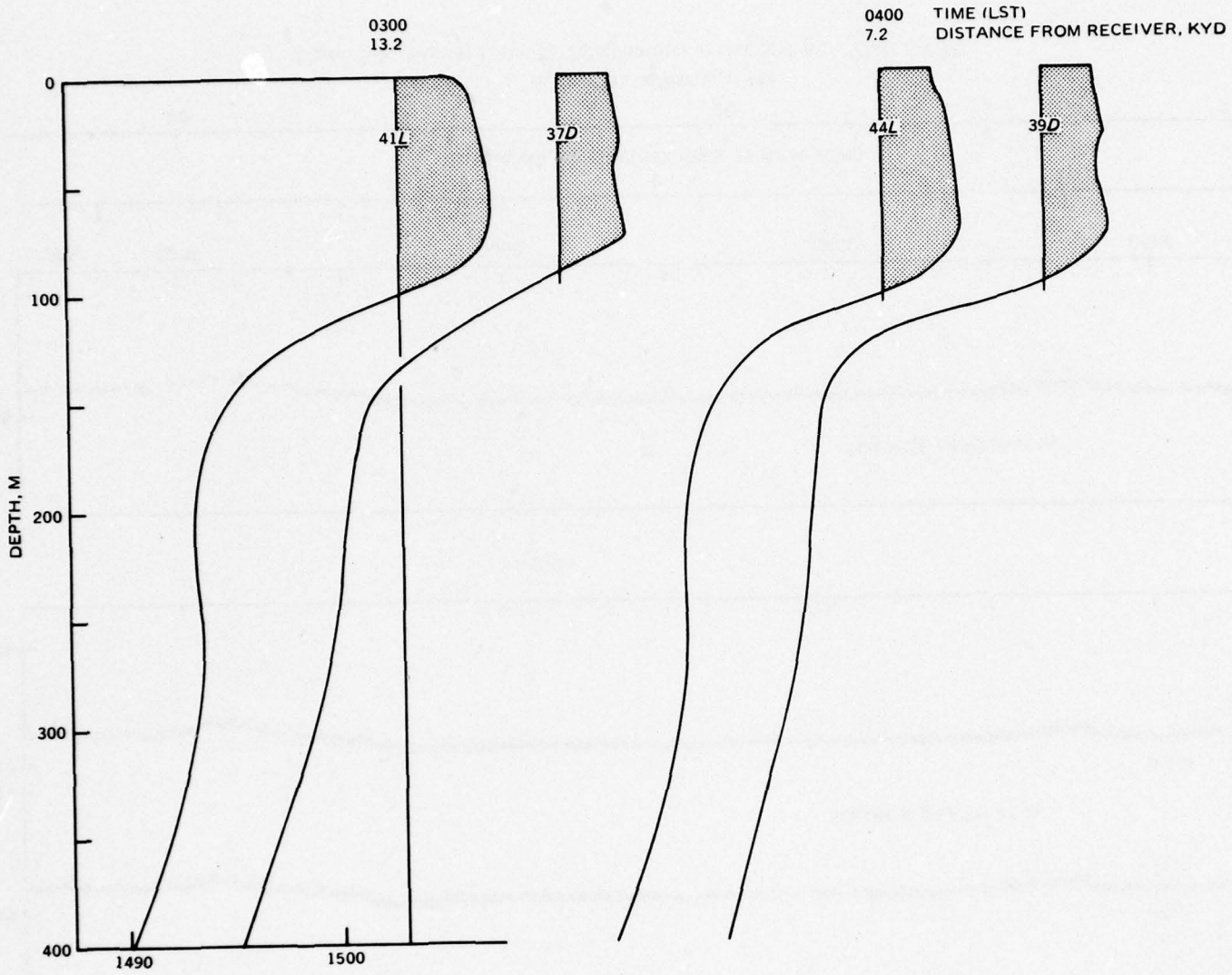

Figure B-6. Station 1, run 2. Spatial change in sound-speed profile.

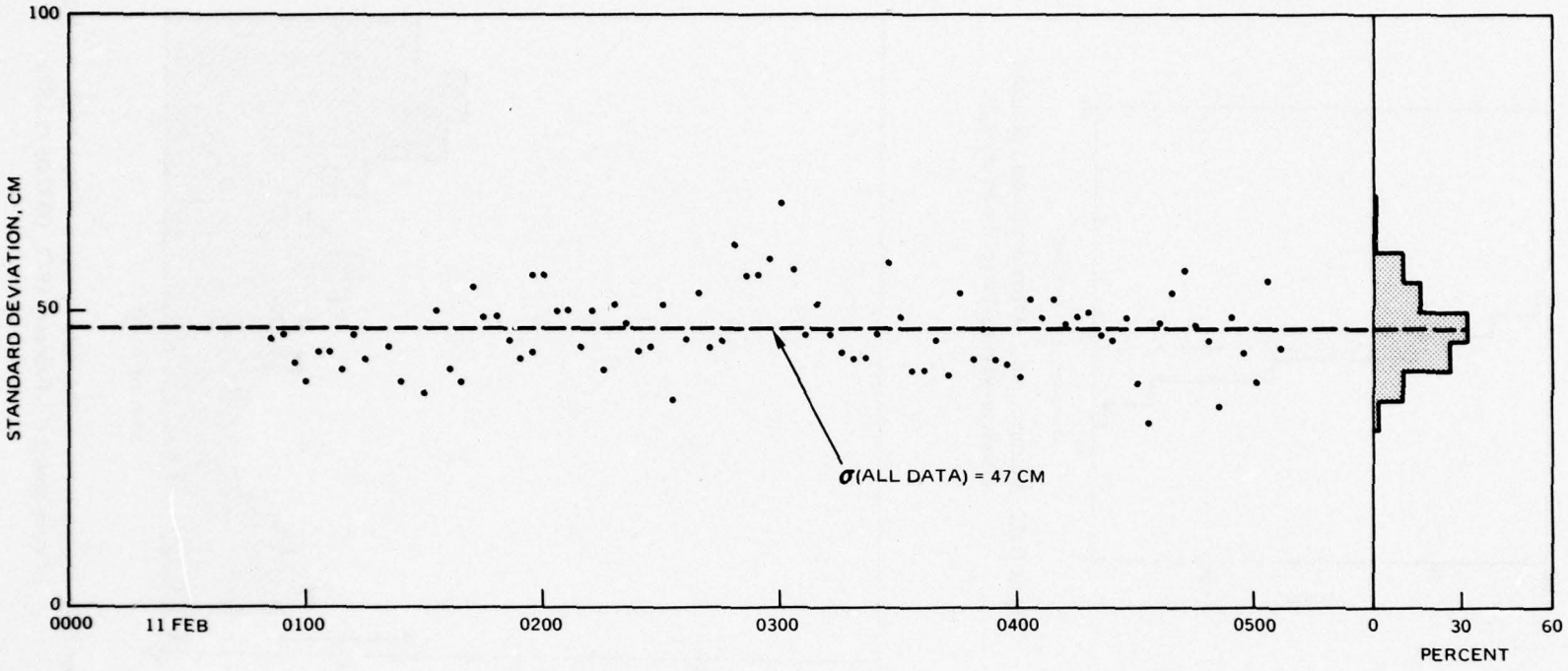

Figure B-7. Standard deviation of surface-wave height for 3-min averages. Time is LST.

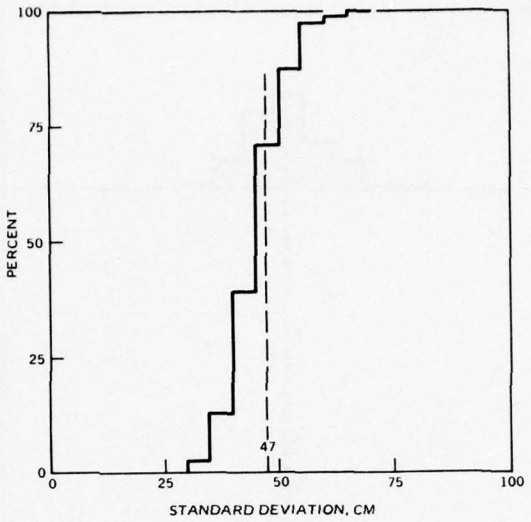

Figure B-8. Station 1, run 2. Ogive of standard deviation of surface-wave height for 3-min averages.

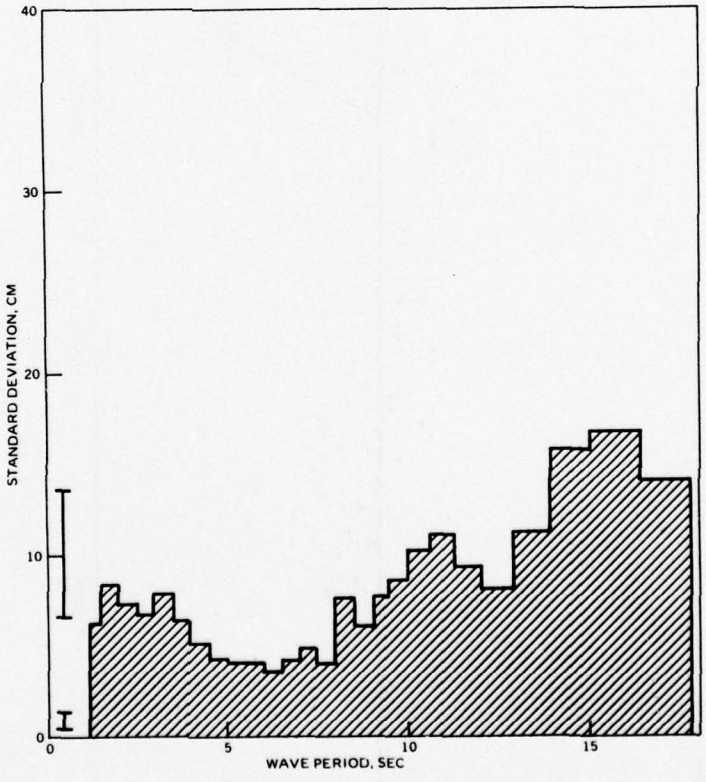

Figure B-9. Station 1, run 2. Standard deviation of wave height as a function of wave period (11 February 1972, 0052-0515 LST).

Table B-1. Temperature Profiles (°C),
Station 1 Run 2 (11 February 1972 0052-0515 LST).

XBT MEASUREMENTS

Depth, m	35L 0100	36L 0120	37L 0140	38L 0200	39L 0221	40L 0240	41L 0300	42L 0320
0	15.0	15.0	15.0	15.0	15.0	15.1	15.1	15.0
10	15.0	15.0	15.0	15.0	15.0	15.1	15.3	15.0
20	14.8	14.9	14.9	15.0	15.0	15.1	15.3	15.0
30	14.8	14.9	14.9	15.0	15.0	15.1	15.3	15.0
50	14.7	14.8	14.8	15.0	15.0	15.1	15.3	15.0
75	14.3	14.4	14.5	14.7	14.7	15.1	15.1	15.0
100	13.1	13.4	13.4	13.3	13.2	13.7	13.8	13.6
125	11.3	11.5	11.5	11.4	11.6	12.0	12.0	11.6
150	10.8	10.7	10.7	10.8	10.9	10.9	11.1	10.9
200	10.1	10.2	10.2	10.4	10.3	10.3	10.4	10.4
250	9.8	9.9	9.9	10.1	10.0	10.0	10.1	10.0
300	9.3	9.4	9.4	9.6	9.6	9.6	9.7	9.6
400	8.3	8.2	8.2	8.4	8.3	8.5	8.4	8.3
ILD	10	16	16	50	50	80	60	80
T	15.0	15.0	15.0	15.0	15.0	15.1	15.3	15.0
SLD	88	87	82	50	91	88	89	80

Depth, m	43L 0340	44L 0400	45L 0420	46L 0440	47L 0500	37D 0248	38D 0400
0	15.1	15.0	15.0	15.0	15.2	15.0	15.0
10	15.1	15.0	15.0	15.0	15.2	15.0	15.0
20	15.1	15.1	15.0	15.0	15.2	15.0	15.0
30	15.0	15.1	15.0	15.0	15.1	15.0	15.0
50	15.0	15.1	15.0	15.0	15.0	14.8	14.8
75	15.0	15.0	14.8	14.8	14.8	14.8	14.8
100	13.7	14.0	13.2	13.0	13.3	13.2	13.7
125	11.9	12.0	11.5	11.8	11.9	11.8	11.2
150	10.9	11.2	10.9	11.0	10.9	10.9	10.5
200	10.4	10.5	10.4	10.6	10.4	10.3	10.0
250	10.0	10.1	10.1	10.2	10.1	9.8	9.6
300	9.7	9.7	9.6	9.7	9.4	9.2	9.0
400	8.4	8.4	8.4	8.5	8.3	7.8	7.8
ILD	80	75	70	70	20	29	32
T	15.0	15.0	15.0	15.0	15.2	15.0	15.0
SLD	80	75	80	75	70	76	78

Table B-2. Computed Sound-Speed Profiles (m/sec),
Station 1 Run 2 (11 February 1972 0052-0515 LST).

XBT MEASUREMENTS

Depth, m	35L 0100	36L 0120	37L 0140	38L 0200	39L 0221	40L 0240	41L 0300	42L 0320
0	1505.3	1505.3	1505.3	1505.3	1505.3	1505.6	1505.6	1505.3
10	05.5	05.5	05.5	05.5	05.5	05.8	06.4	05.5
20	05.0	05.3	05.3	05.6	05.6	06.0	06.6	05.6
30	05.2	05.5	05.5	05.8	05.8	06.1	06.8	05.8
50	05.2	05.5	05.5	06.2	06.2	06.5	07.1	06.2
75	04.2	04.6	04.9	05.6	05.6	06.9	06.9	06.6
100	00.7	01.7	01.7	01.4	01.0	02.7	03.1	02.4
125	1495.0	1495.7	1495.7	1495.3	1496.0	1497.4	1497.4	1496.0
150	93.7	93.4	93.4	93.7	94.1	94.1	94.8	94.1
200	92.3	92.6	92.6	93.3	93.0	93.0	03.3	93.3
250	92.4	92.8	92.8	93.4	93.1	93.1	93.5	93.1
300	91.7	92.0	92.0	92.8	92.8	92.8	93.2	92.8
400	89.7	89.3	89.3	90.1	89.7	90.5	90.1	89.7
SC	10	16	16	50	50	80	60	80
DC	20	20	20					
MAX	40	40	40					
RC	200	190	190	190	200	200	200	
MAX	250	250	225	250	260	250	260	

Table B-2, continued.

Depth, m	43L 0340	44L 0400	45L 0420	46L 0440	47L 0500	37D 0248	38D 0400
0	1505.6	1505.3	1505.3	1505.3	1506.0	1505.3	1505.3
10	05.8	05.5	05.5	05.5	06.1	05.5	05.5
20	06.0	06.0	05.6	05.6	06.3	05.6	05.6
30	05.8	06.1	05.8	05.8	06.1	05.8	05.8
50	06.2	06.5	06.2	06.2	06.2	05.5	05.5
75	06.6	06.6	05.9	05.9	05.9	05.9	05.9
100	02.7	03.8	01.0	00.3	01.4	01.0	02.7
125	1497.1	1497.4	1495.7	1496.7	1497.1	1496.7	1494.6
150	94.1	95.1	94.1	94.4	94.1	94.1	92.7
200	93.3	93.7	93.3	94.0	93.3	93.0	91.9
250	93.1	93.5	93.5	93.9	93.5	92.4	91.6
300	93.2	93.2	92.8	93.2	92.0	91.3	90.5
400	90.1	90.1	90.1	90.5	89.7	87.7	87.7
SC	20	75	70	70	20	30	30
DC	30				30	50	50
MAX	75				50	75	75
RC	250		200		200		
MAX	300		250		250		

Table B-3. Average Sound-Speed Profile (m/sec), Station 1 Run 2 (11 February 1972 0052-0515 LST).

Depth, m	Number of Observations	Average Speed	Standard Deviation
0	1350	1505.29	0.13
10	1350	05.41	0.13
20	1350	05.44	0.16
30	1350	05.46	0.16
50	1350	05.47	0.26
75	1350	05.25	0.57
100	1350	00.61	0.94
125	1350	1495.80	0.60
150	1350	93.38	0.32
200	1350	92.48	0.25
250	1350	92.37	0.19
300	22	92.45	0.72
400	20	89.79	0.90
500	4	87.54	0.68
600	4	85.79	0.75
800	6	83.59	0.29
1000	5	83.54	0.19
1200	5	84.57	0.13
1500	5	86.66	0.09
68		1505.48	SC
900		1483.40	AXIS

Table B-4. Average Thermistor Chain Temperatures
Station 1 Run 2 (number of measurements at each depth: 1350).

Depth, m	Temperature, °C Min	Max	Mean	Standard Deviation
0	14.85	15.07	14.99	0.037
6	14.85	15.07	14.98	0.038
11	14.82	15.07	14.98	0.040
17	14.77	15.05	14.95	0.049
23	14.72	15.02	14.92	0.059
28	14.72	15.02	14.90	0.054
34	14.70	14.97	14.87	0.052
39	14.60	14.97	14.87	0.061
45	14.62	15.00	14.84	0.068
51	14.47	14.90	14.77	0.082
56	14.50	14.95	14.80	0.097
62	14.42	14.90	14.75	0.115
68	14.37	14.87	14.70	0.138
73	14.27	14.85	14.61	0.165
79	14.07	14.90	14.54	0.208
85	13.67	14.80	14.28	0.262
90	13.15	14.50	13.85	0.330
96	12.92	14.37	13.57	0.311
101	12.30	13.52	12.97	0.274
107	11.97	13.17	12.61	0.263
113	11.55	12.77	12.20	0.257
118	11.42	12.42	11.88	0.203
124	11.07	12.07	11.60	0.174
130	10.92	11.72	11.30	0.165
135	10.77	11.42	11.05	0.117
141	10.65	11.10	10.92	0.098
147	10.50	11.02	10.81	0.093
152	10.32	10.82	10.62	0.094
158	10.27	10.72	10.55	0.082
164	10.22	10.60	10.45	0.083
169	10.20	10.55	10.39	0.077
175	10.12	10.52	10.34	0.079
180	10.12	10.47	10.29	0.081
186	10.02	10.40	10.23	0.075
192	10.02	10.40	10.20	0.076
197	10.00	10.37	10.17	0.072
203	9.97	10.35	10.15	0.072
209	9.92	10.25	10.10	0.070
214	9.87	10.22	10.06	0.063
220	9.92	10.15	10.02	0.041
226	9.87	10.07	9.96	0.035
231	9.77	10.02	9.91	0.041
237	9.75	9.97	9.89	0.037
242	9.65	9.95	9.85	0.046

Table B-5. Standard Deviation (cm) of Wave Height for 3-Min Averages, Station 1 Run 2 (11 February 1972 0052-0515 LST).

	Hours					
Minutes	0000	0100	0200	0300	0400	0500
01		38	56	68	39	38
04		43	50	57	52	55
07		43	50	46	49	44
10		40	47	51	52	47
13		46	50	46	48	
16		42	40	43	49	
19		47	51	42	50	
22		44	48	42	46	
25		38	43	46	45	
28		43	44	58	49	
31		36	51	49	38	
34		50	35	40	31	
37		40	45	40	48	
40		35	53	45	53	
43		54	44	39	57	
46		49	45	53	48	
49		49	61	42	45	
52	45	45	56	47	34	
55	46	42	56	42	49	
58	41	56	59	41	43	

Table B-6. Standard Deviation of Wave Height as a Function of Wave Period, Station 1 Run 2 (11 February 1972 0052-0515 LST).

Wave-Period Band, sec	Standard Deviation, cm	Wave-Period Band, sec	Standard Deviation, cm
1.2 – 1.4	6.3	7.5 – 7.9	4.1
1.5 – 1.9	8.4	8.0 – 8.5	7.5
2.0 – 2.4	7.3	8.6 – 9.0	6.3
2.5 – 2.9	6.7	9.1 – 9.4	7.7
3.0 – 3.4	7.9	9.5 – 9.9	8.6
3.5 – 3.9	6.3	10.0 – 10.5	10.2
4.0 – 4.4	5.0	10.6 – 11.2	11.1
4.5 – 4.9	4.3	11.3 – 11.9	9.3
5.0 – 5.4	4.0	12.0 – 12.8	8.1
5.5 – 5.9	4.0	12.9 – 13.8	11.2
6.0 – 6.4	3.5	13.9 – 14.9	15.7
6.5 – 6.9	4.3	15.0 – 16.3	16.7
7.0 – 7.4	4.9	16.4 – 17.8	14.2

APPENDIX C

STATION 1 RUN 3

DETAILED ENVIRONMENTAL SUMMARY

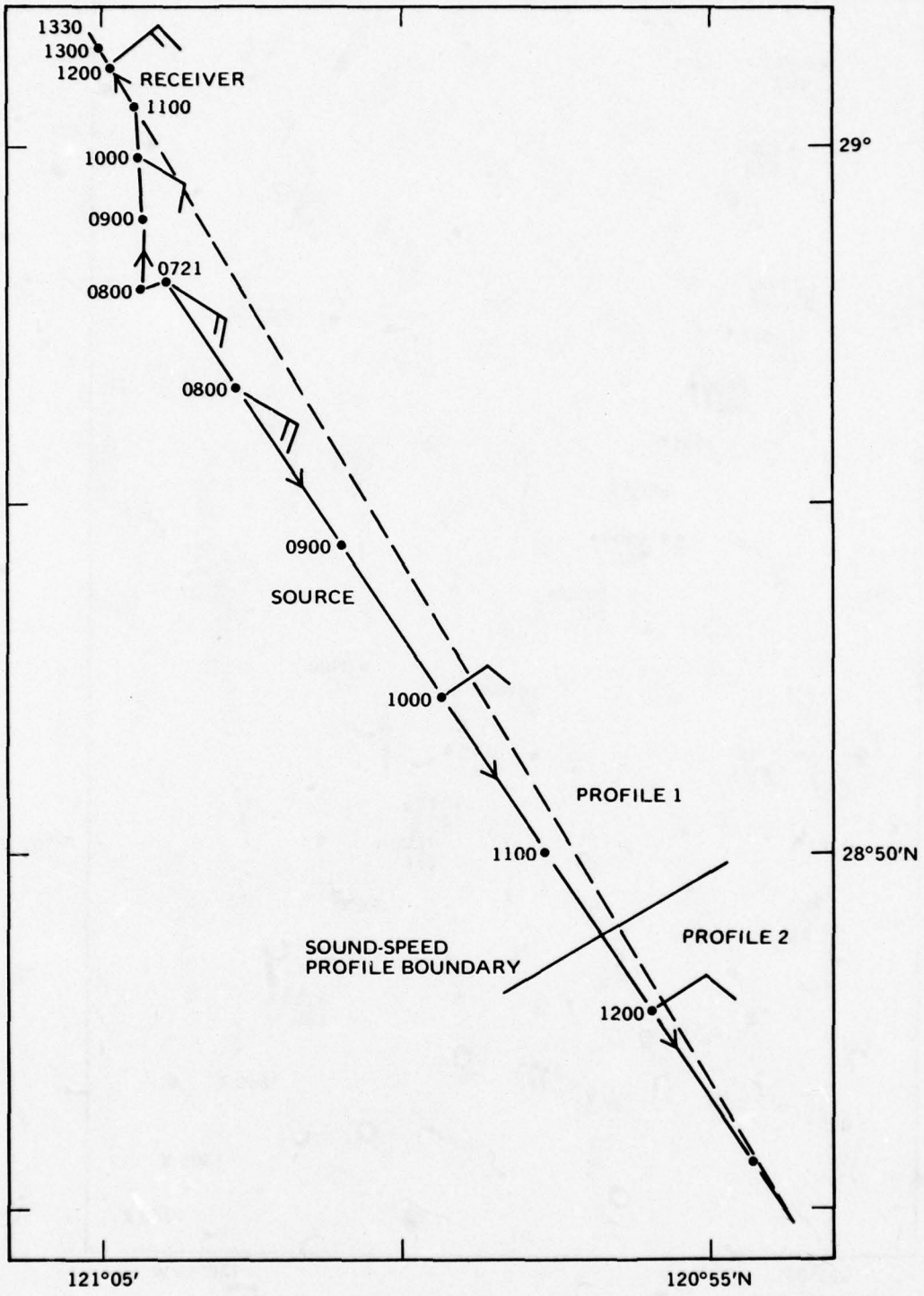

Figure C-1. Station 1, run 3. Location of source and receiver ships, 1330 LST propagation path (---), and wind velocity (10-knot east wind, 1 bar = 5 knots).

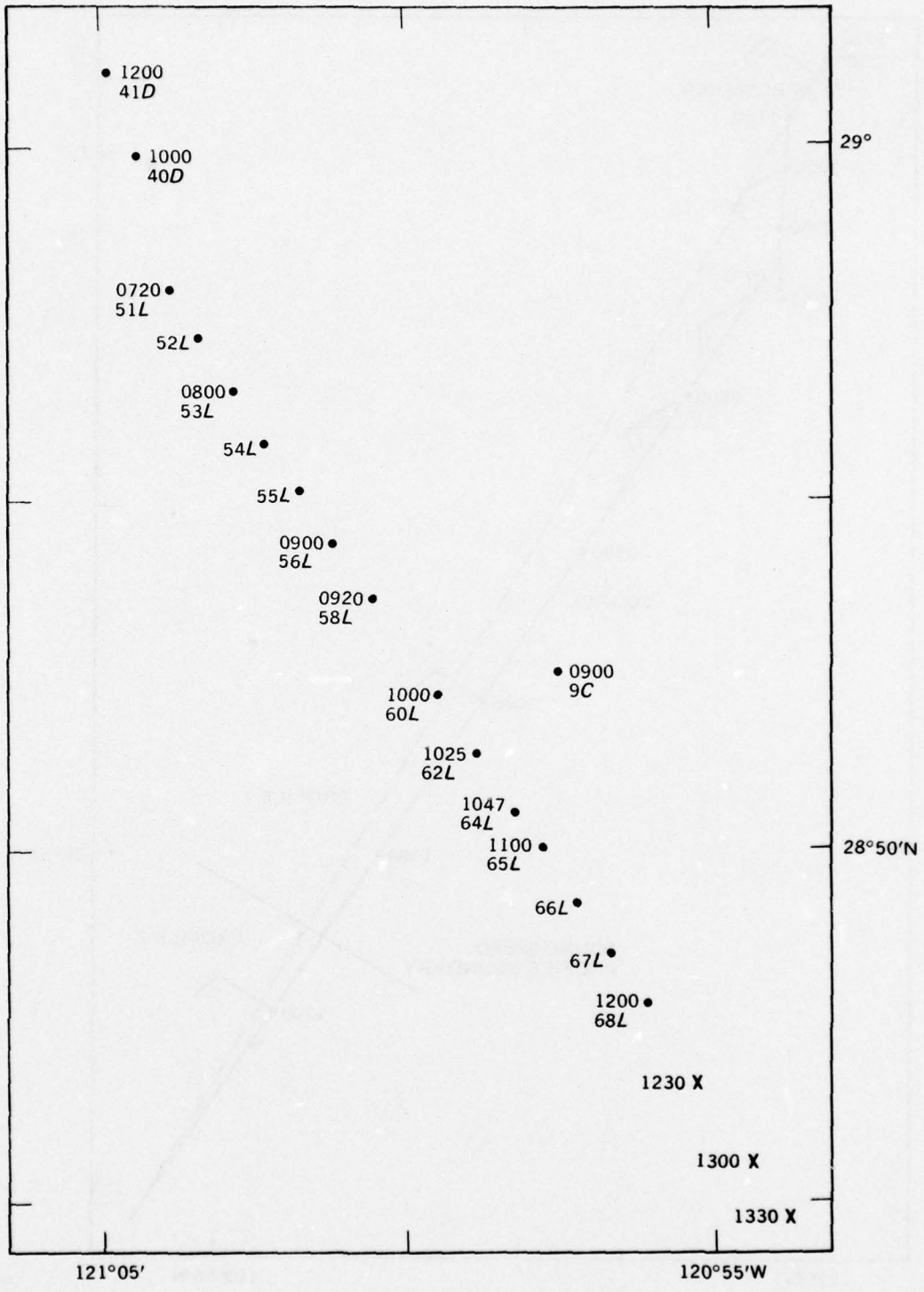

Figure C-2. Station 1, run 3. Location of XBT (·) and thermistor chain (X) measurements. The letter following the XBT number denotes the ship which took the measurement (*L:Lee, D:DeSteiguer, C:Cape*). The times shown are LST.

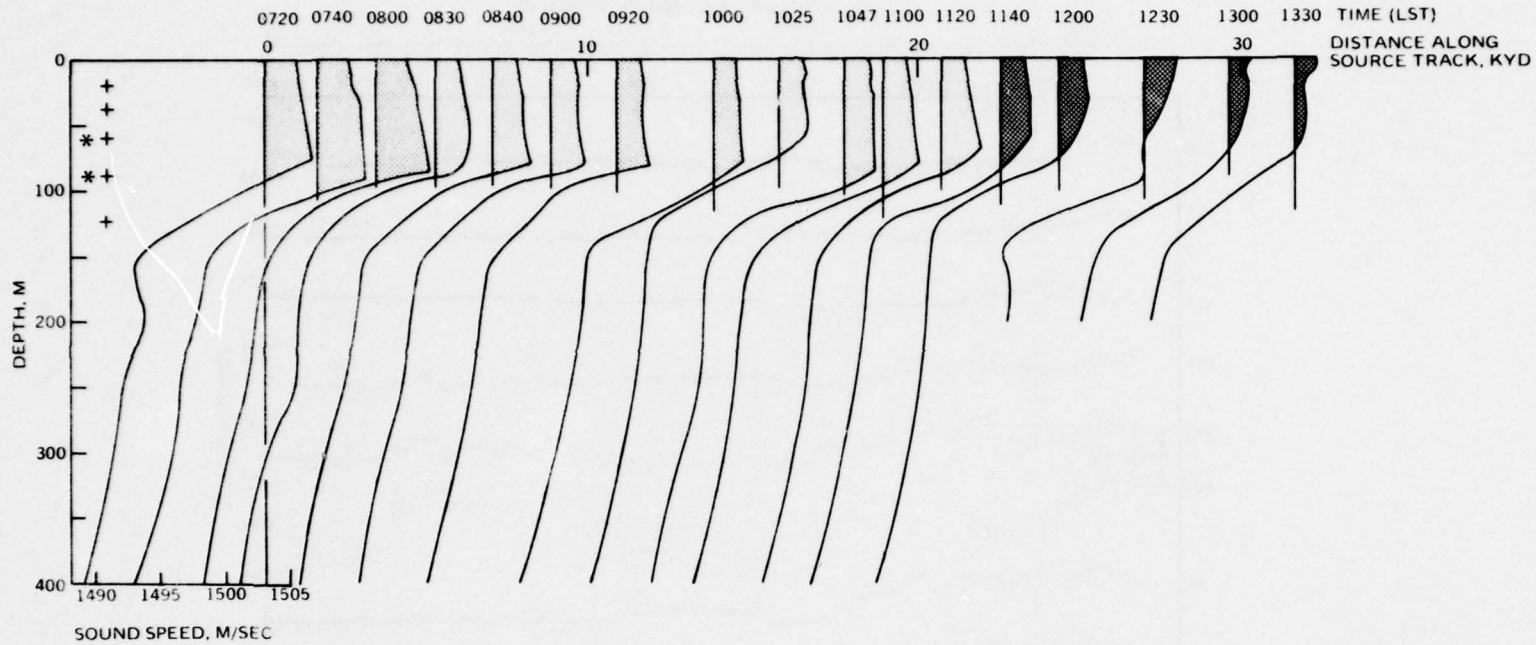

Figure C-3. Station 1, run 3. Sound-speed profile along track of source ship derived from XBT and thermistor chain data. Source depth (*), receiver depths (+).

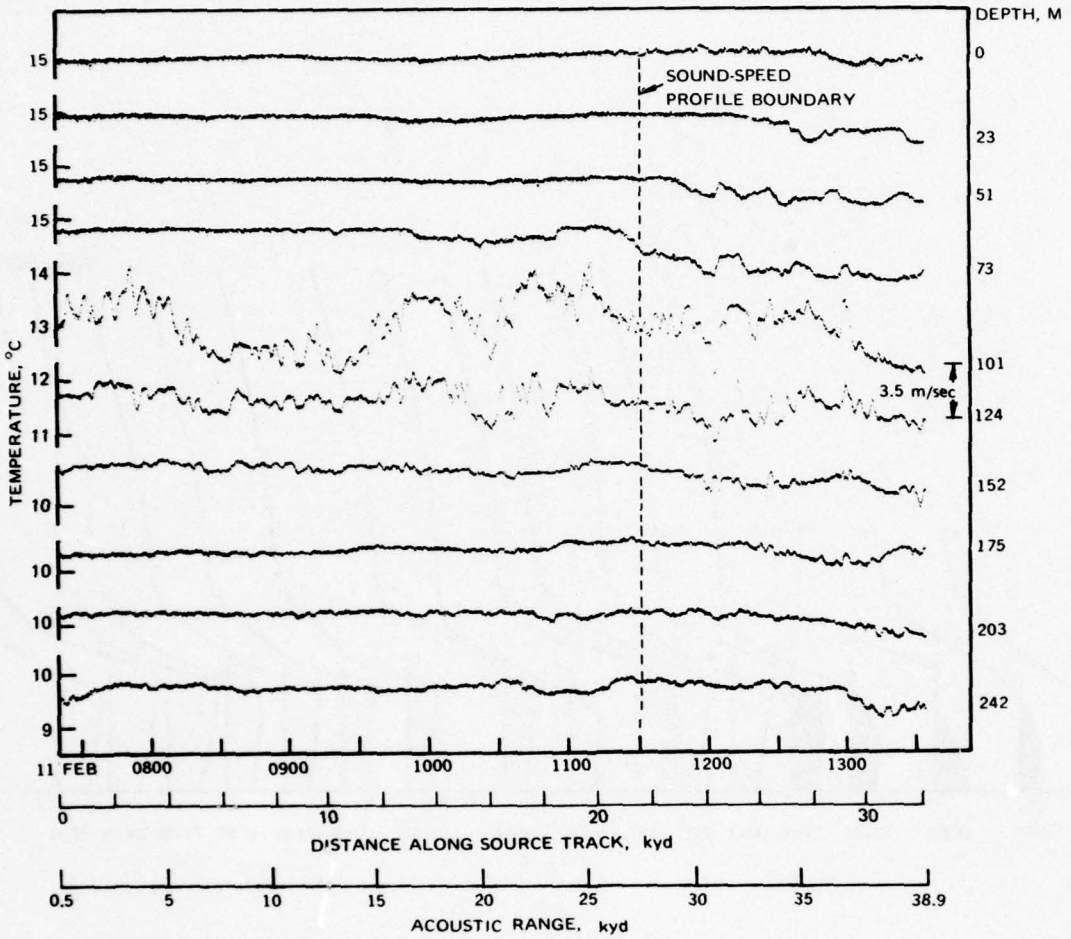

Figure C-4. Station 1, run 3. Thermistor chain temperature measurements at selected depths. Time is LST.

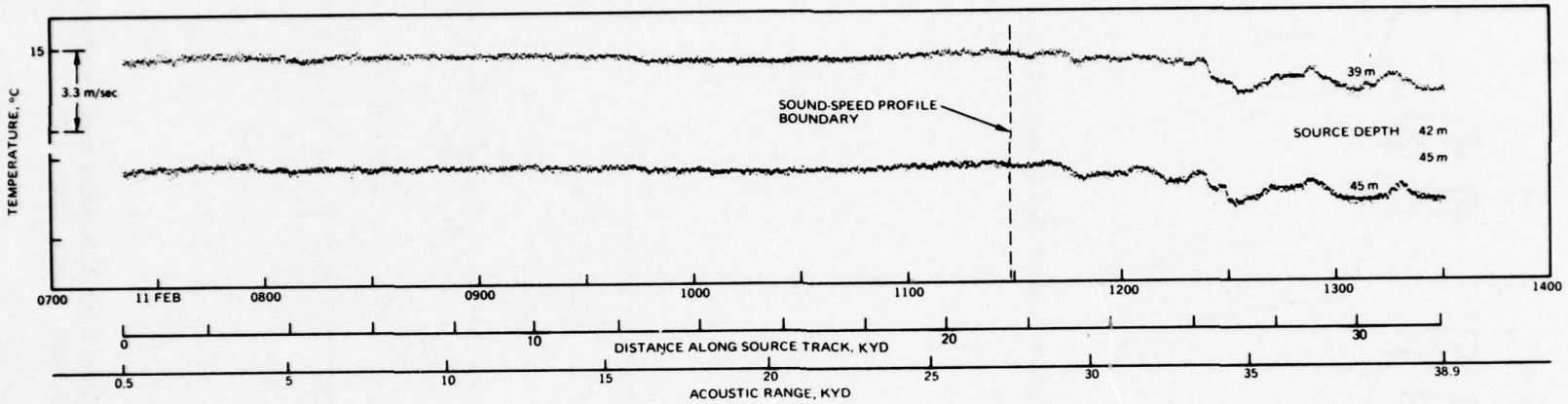

Figure C-5. Station 1, run 3. Temperatures above and below source depths. Time is LST.

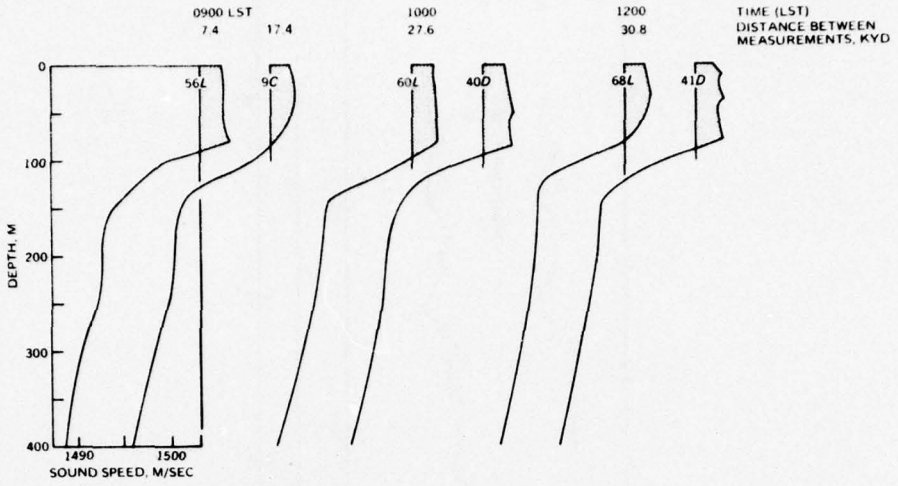

Figure C-6. Station 1, run 3. Spatial change in sound-speed profiles.

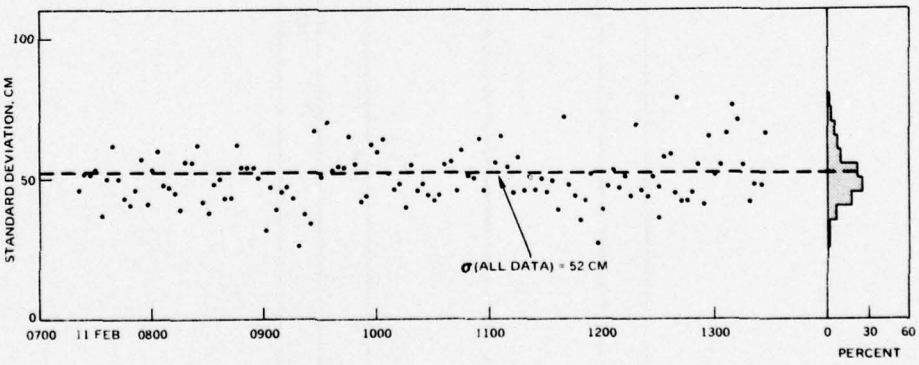

Figure C-7. Station 1, run 3. Standard deviation of surface-wave height for 3-min averages. Time is LST.

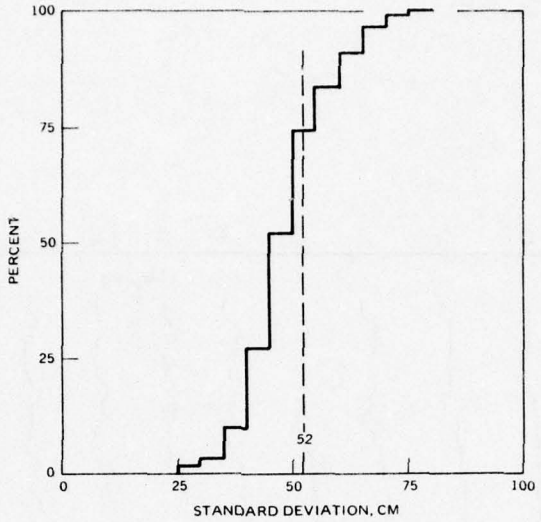

Figure C-8. Station 1, run 3. Ogive of standard deviation of surface-wave height for 3-min averages.

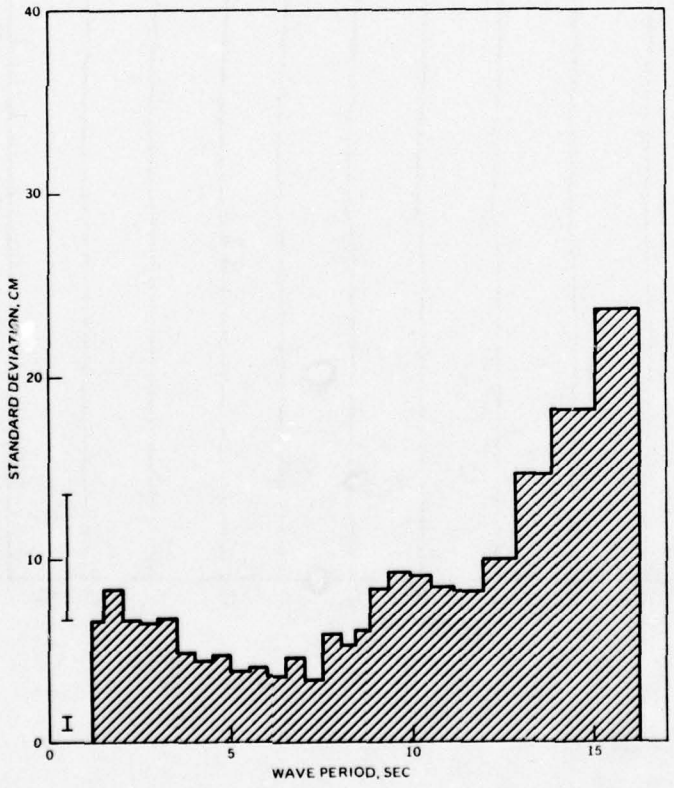

Figure C-9. Station 1, run 3. Standard deviation of wave height as a function of wave period (11 February 1972, 0721-1320 LST).

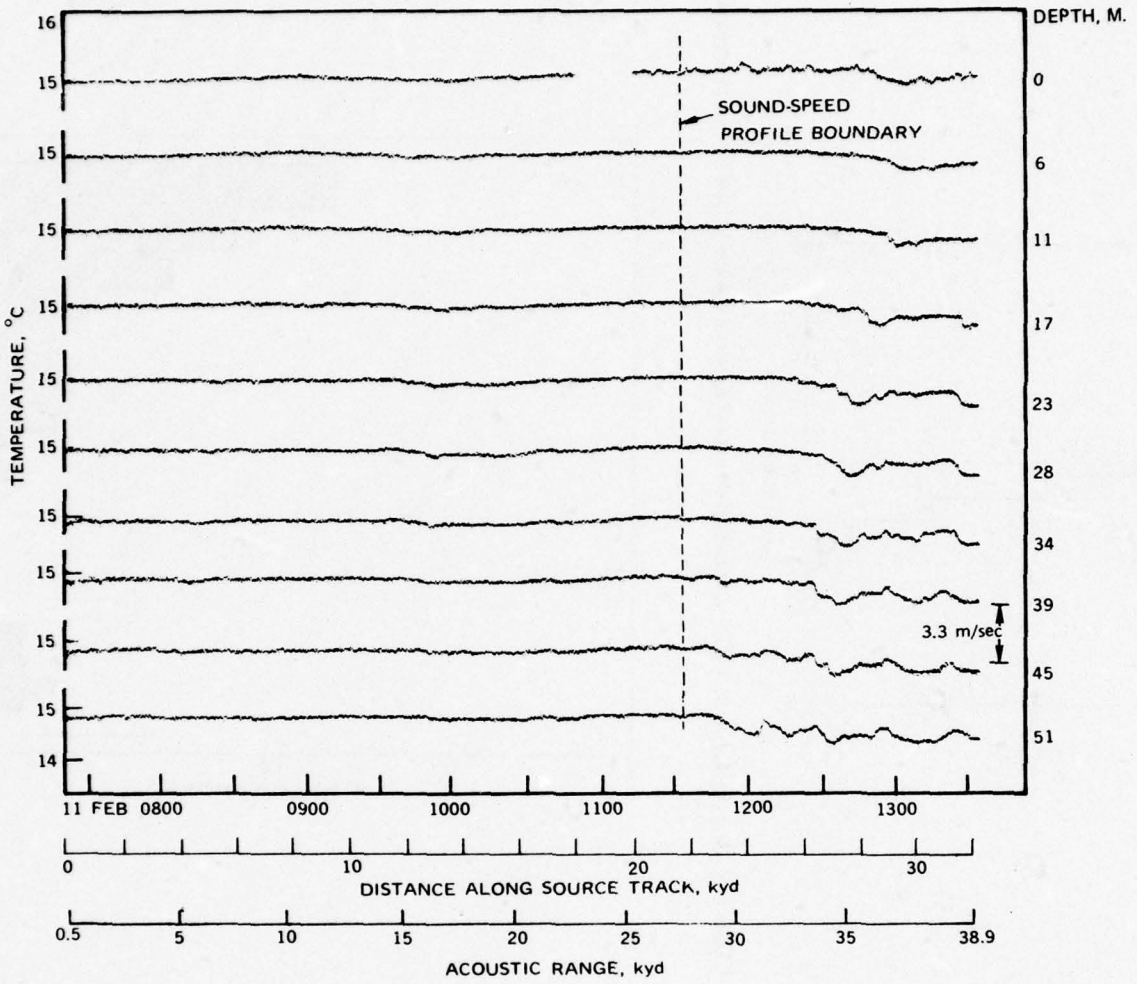

Figure C-11. Station 1, run 3. Thermistor chain temperature measurements for about 6-m depth intervals between the surface and 51 m. Time is LST.

Table C-1. Temperature Profiles (°C),
Station 1 Run 3 (11 February 1972 0721–1330 LST).

XBT MEASUREMENTS

Depth, m	51L 0720	52L 0740	53L 0800	54L 0820	55L 0840	56L 0900	58L 0920	60L 1000
0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
10	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.9
20	15.0	15.0	15.1	15.0	15.0	15.0	15.0	14.9
30	15.0	15.1	15.1	15.0	15.0	14.9	14.9	14.9
50	15.0	15.1	15.1	15.0	14.9	14.8	14.8	14.8
75	15.0	15.0	15.1	14.8	14.9	14.8	14.8	14.7
100	13.3	14.0	13.2	12.8	12.8	12.7	12.6	13.6
125	11.8	12.0	11.8	11.5	11.7	11.7	11.8	12.0
150	10.7	11.1	11.2	10.9	10.8	10.8	10.9	10.8
200	10.5	10.5	10.5	10.3	10.3	10.2	10.3	10.4
250	9.7	9.8	10.0	9.9	9.7	9.7	9.8	9.8
300	9.2	9.4	9.3	9.0	9.0	9.0	9.2	9.2
400	8.1	8.1	8.3	8.0	8.0	8.0	8.1	8.0
ILD	75	88	90	50	40	20	20	0
T	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
SLD	75	88	90	87	80	80	80	80

Depth, m	62L 1025	64L 1047	65L 1100	66L 1120	67L 1140	68L 1200
0	15.0	15.0	15.0	15.0	15.0	15.0
10	15.0	15.0	15.0	15.0	15.0	15.0
20	14.9	15.0	15.0	15.0	15.0	15.0
30	14.9	15.0	15.0	15.0	15.0	15.0
50	14.9	14.9	14.9	15.0	14.9	14.7
75	14.0	14.8	14.9	14.8	14.4	14.1
100	12.4	13.8	13.6	12.9	13.3	12.4
125	10.0	11.4	11.8	11.7	11.2	11.1
150	10.7	10.7	10.8	10.9	10.7	10.8
200	10.3	10.2	10.2	10.4	10.3	10.4
250	9.8	9.8	9.7	10.0	9.8	9.9
300	9.2	9.1	9.2	9.4	9.2	9.4
400	8.1	8.0	8.1	8.3	8.1	8.2
ILD	10	30	30	70	30	30
T	15.0	15.0	15.0	15.0	15.0	15.0
SLD	70	85	80	85	60	48

Table C-1, continued.

	XBT MEASUREMENTS			THERMISTOR CHAIN MEASUREMENTS		
Depth, m	40D 1000	41D 1200	9C 0900	1230	1300	1330
0	15.0	15.1	14.9	15.1	14.9	15.0
10	15.0	15.1	14.9	15.0	14.6	14.8
20	15.0	15.0	14.9	14.8	14.7	14.5
30	15.0	15.0	14.9	14.7	14.6	14.4
50	15.0	14.8	14.7	14.3	14.3	14.4
75	14.8	14.8	14.2	13.9	13.9	13.9
100	13.3	12.8	13.2	13.2	12.8	12.2
125	11.6	11.4	11.5	11.2	11.3	11.2
150	10.9	10.6	10.7	10.4	10.5	10.4
200	10.2	10.2	10.2	10.2	10.0	9.8
250	9.7	9.6	9.7	9.8	9.5	9.4
300	9.2	9.0	9.0			
400	8.0	8.0	7.9			
ILD	50	10	30	0	0	0
T	15.0	15.1	14.9	15.1	14.9	15.0
SLD	86	78	82	90	90	90

Table C-2. Computed Sound-Speed Profiles (m/sec), Station 1 Run 3 (11 February 1972 0721-1330 LST).

XBT MEASUREMENTS

Depth, m	51L 0720	52L 0740	53L 0800	54L 0820	55L 0840	56L 0900	58L 0920	60L 1000
0	1505.3	1505.3	1505.3	1505.3	1505.3	1505.3	1505.3	1505.3
10	05.5	05.5	05.5	05.5	05.5	05.5	05.5	05.2
20	05.6	05.6	06.0	05.6	05.6	05.6	05.6	05.3
30	05.8	06.1	06.1	05.8	05.8	05.5	05.5	05.5
50	06.2	06.5	06.5	06.2	05.8	05.5	05.5	05.5
75	06.6	06.6	06.9	05.9	06.2	05.9	05.9	05.6
100	01.4	03.8	01.0	1499.6	1499.6	1499.3	1498.9	02.4
125	1496.7	1497.4	1496.7	95.7	96.4	96.4	96.7	1497.4
150	93.4	94.8	95.1	94.1	93.7	93.7	94.1	93.7
200	93.7	93.7	93.7	93.0	93.0	92.6	93.0	93.3
250	92.0	92.4	93.1	92.8	92.0	92.0	92.4	92.4
300	92.3	92.0	91.7	90.5	90.5	90.5	91.3	91.3
400	88.9	88.9	89.7	88.5	88.5	88.5	88.9	88.5
SC	75	88	85	50	80	20	20	0
DC						40	40	10
MAX						80	80	80
RC	160							
MAX	200							

Depth, m	62L 1025	64L 1047	65L 1100	66L 1120	67L 1140	68L 1200
0	1505.3	1505.3	1505.3	1505.3	1505.3	1505.3
10	05.5	05.5	05.5	05.5	05.5	05.5
20	05.3	05.6	05.6	05.6	05.6	05.6
30	05.5	05.8	05.8	05.8	05.8	05.8
50	05.8	05.8	05.8	06.2	05.8	05.2
75	03.2	05.9	06.2	05.9	04.6	03.6
100	1498.2	03.1	02.4	00.0	01.4	1498.2
125	93.9	1495.3	1496.7	1496.4	1494.6	94.3
150	93.4	93.4	93.7	94.1	93.4	93.7
200	93.0	92.6	92.6	93.3	93.0	93.3
250	92.4	92.4	92.0	93.1	92.4	92.8
300	91.3	90.9	91.3	92.0	91.3	92.0
400	88.9	88.5	88.9	89.7	88.9	89.3
SC	10	85	80	70	60	30
DC	20					
MAX	50					

Table C-2, continued.

	XBT MEASUREMENTS			THERMISTOR CHAIN MEASUREMENTS		
Depth, *m*	40D 1000	41D 1200	9C 0900	1230	1300	1330
0	1505.3	1505.0	1505.0	1505.5	1504.9	1505.2
10	05.5	05.8	05.2	05.4	04.2	04.7
20	05.6	05.6	05.3	05.1	04.5	03.8
30	05.8	05.8	05.5	04.7	04.6	03.9
50	06.2	05.5	05.2	03.9	04.0	04.0
75	05.9	05.9	03.9	02.9	02.8	02.8
100	01.4	1499.6	01.0	01.1	1499.6	1497.6
125	1496.0	95.3	1495.7	1494.6	95.1	94.6
150	94.1	93.0	93.4	92.2	92.8	92.1
200	92.6	92.6	92.6	92.6	91.7	91.0
250	92.0	91.6	92.0			
300	91.3	90.5	90.5			
400	88.5	88.5	88.1			
SC	50	10	30	0	0	0
DC	52	20		73	10	20
MAX	86	38		90	30	30
DC		40				
MAX		78				
RC				152		
MAX				169		

Table C-3. Average Sound-Speed Profiles (m/sec), Station 1 Run 3 (11 February 1972 0721-1330 LST).

Depth,	Profile 1 0720–1130			Profile 2 1132–1330		
m	n	$\overline{C}$	σ	n	$\overline{C}$	σ
0	1503	1505.35	0.16	711	1505.48	0.24
10	1503	05.38	0.13	711	05.05	0.39
20	1503	05.44	0.13	711	04.96	0.56
30	1503	05.49	0.16	711	04.88	0.55
50	1503	05.50	0.10	711	04.52	0.49
75	1503	05.61	0.47	711	03.23	0.54
100	1503	01.37	1.62	711	00.16	1.39
125	1503	1496.22	0.74	711	1495.17	0.74
150	1503	93.66	0.28	711	92.57	0.49
200	1503	92.73	0.15	711	92.20	0.57
250	1503	92.03	0.31	711	91.62	0.76
300	21	91.59	0.82	4	91.15	0.68
400	19	89.20	0.85	5	89.66	0.47
500	4	87.54	0.68			
600	4	85.79	0.75			
800	6	83.59	0.29			
1000	5	83.54	0.19			
1200	5	84.57	0.13			
1500	5	86.66	0.09			
79		1505.63				SC
152					1492.55	RC
169					1493.10	MAX
900		1483.35			1483.35	AXIS

Table C-4. Average Thermistor Chain Temperatures, Station 1 Run 3, **Profile 1** (number of measurements at each depth: 1503).

Depth, m	Temperature, °C			Standard Deviation
	Min	Max	Mean	
0	14.82	15.12	15.01	0.045
6	14.85	15.05	14.97	0.036
11	14.85	15.05	14.97	0.038
17	14.82	15.02	14.95	0.040
23	14.80	15.00	14.93	0.045
28	14.75	15.00	14.91	0.048
34	14.75	14.95	14.88	0.044
39	14.75	14.97	14.87	0.041
45	14.75	14.95	14.84	0.037
51	14.67	14.87	14.78	0.032
56	14.70	14.90	14.81	0.033
62	14.57	14.90	14.79	0.043
68	14.50	14.87	14.78	0.069
73	14.30	14.85	14.72	0.095
79	14.12	14.87	14.70	0.138
85	15.77	14.85	14.49	0.240
90	15.17	14.80	14.11	0.364
96	12.62	14.67	13.80	0.432
101	12.10	14.17	13.07	0.477
107	11.97	13.72	12.66	0.385
113	11.77	13.12	12.33	0.280
118	11.35	12.67	12.01	0.223
124	11.07	12.22	11.69	0.205
130	10.92	11.87	11.39	0.165
135	10.65	11.47	11.16	0.152
141	10.57	11.40	10.99	0.153
147	10.60	11.22	10.87	0.118
152	10.47	10.87	10.69	0.080
158	10.45	10.80	10.61	0.077
164	10.32	10.65	10.50	0.065
169	10.27	10.65	10.42	0.080
175	10.17	10.60	10.38	0.075
180	10.17	10.55	10.36	0.067
186	10.17	10.45	10.30	0.056
192	10.15	10.42	10.28	0.046
197	10.12	10.35	10.24	0.033
203	10.02	10.30	10.21	0.041
209	9.97	10.25	10.14	0.047
214	9.87	10.17	10.07	0.052
220	9.85	10.17	10.02	0.059
226	9.75	10.07	9.93	0.070
231	9.65	9.97	9.82	0.070
237	9.57	9.97	9.77	0.080
242	9.45	9.95	9.74	0.076

Table C-4, continued. **Profile 2** (number of measurements at each depth: 711).

Depth, m	Temperature, °C Min	Max	Mean	Standard Deviation
0	14.82	15.25	15.05	0.098
6	14.57	15.05	14.88	0.125
11	14.60	15.02	14.87	0.122
17	14.45	15.00	14.81	0.155
23	14.40	15.00	14.76	0.180
28	14.37	14.97	14.72	0.172
34	14.37	14.95	14.68	0.166
39	14.32	14.92	14.65	0.167
45	14.32	14.90	14.60	0.156
51	14.20	14.82	14.48	0.148
56	14.25	14.87	14.51	0.145
62	14.15	14.82	14.38	0.146
68	13.90	14.70	14.21	0.153
73	13.75	14.37	14.01	0.161
79	13.72	14.30	13.97	0.139
85	13.60	14.22	13.89	0.132
90	13.17	14.12	13.75	0.192
96	12.67	13.87	13.50	0.312
101	12.07	13.47	12.85	0.399
107	11.60	13.35	12.62	0.274
113	11.27	13.07	12.23	0.254
118	10.97	12.40	11.77	0.253
124	10.82	12.00	11.39	0.208
130	10.67	11.50	11.07	0.141
135	10.57	11.15	10.84	0.101
141	10.47	10.97	10.71	0.090
147	10.25	10.85	10.59	0.129
152	9.92	10.70	10.41	0.137
158	9.82	10.67	10.41	0.169
164	9.82	10.60	10.40	0.146
169	10.17	10.60	10.41	0.100
175	10.02	10.52	10.33	0.140
180	9.97	10.50	10.26	0.145
186	9.87	10.45	10.19	0.162
192	9.80	10.40	10.16	0.177
197	9.62	10.35	10.09	0.170
203	9.72	10.30	10.06	0.149
209	9.67	10.25	9.99	0.164
214	9.55	10.17	9.93	0.162
220	9.42	10.10	9.88	0.167
226	9.32	10.05	9.82	0.158
231	9.25	9.97	9.73	0.176
237	9.20	9.95	9.70	0.198
242	9.15	9.90	9.65	0.203

Table C-5. Standard Deviation (cm) of Wave Height for 3-Min Averages, Station 1 Run 3 (11 February 1972 0721–1330 LST).

	Hours						
Minutes	0700	0800	0900	1000	1100	1200	1300
00		53	32	60		39	52
03		60	47	64	56	47	55
06		48	39	52	65	53	66
09		47	45	46	54	47	76
12		45	47	48	45	51	71
15		39	43	40	57	44	55
18		56	26	55	46	69	42
21	46	56	37	46	51	46	48
24	52	62	34	48	46	44	48
27	52	42	67	44	50	51	66
30	53	38	51	42	45	47	
33	37	48	70	44	49	48	
36	50	50	53	55	39	49	
39	62	43	54	56	72	45	
42	50	43	54	46	48	42	
45	43	62	65	60	44	42	
48	41	54	55	51	35	45	
51	46	54	42	50	42	55	
54	57	54	44	64	52	41	
57	41	50	62	46	27	65	

Table C-6. Standard Deviation of Wave Height as a Function of Wave Period, Station 1 Run 3 (11 February 1972 0721–1330 LST).

Wave-Period Band, Sec	Standard Deviation, cm	Wave-Period Band, sec	Standard Deviation, cm
1.2 – 1.4	6.6	7.5 – 7.9	5.9
1.5 – 1.9	8.3	8.0 – 8.3	5.3
2.0 – 2.4	6.6	8.4 – 8.7	6.1
2.5 – 2.9	6.5	8.8 – 9.2	8.4
3.0 – 3.4	6.7	9.3 – 9.8	9.3
3.5 – 3.9	4.9	9.9 – 10.4	9.1
4.0 – 4.4	4.4	10.5 – 11.0	8.5
4.5 – 4.9	4.7	11.1 – 11.8	8.3
5.0 – 5.4	3.9	11.9 – 12.7	10.0
5.5 – 5.9	4.0	12.8 – 13.7	14.7
6.0 – 6.4	3.6	13.8 – 14.9	18.2
6.5 – 6.9	4.6	15.0 – 16.1	23.7
7.0 – 7.4	3.4		

APPENDIX D

STATION 1 RUN 4

DETAILED ENVIRONMENTAL SUMMARY

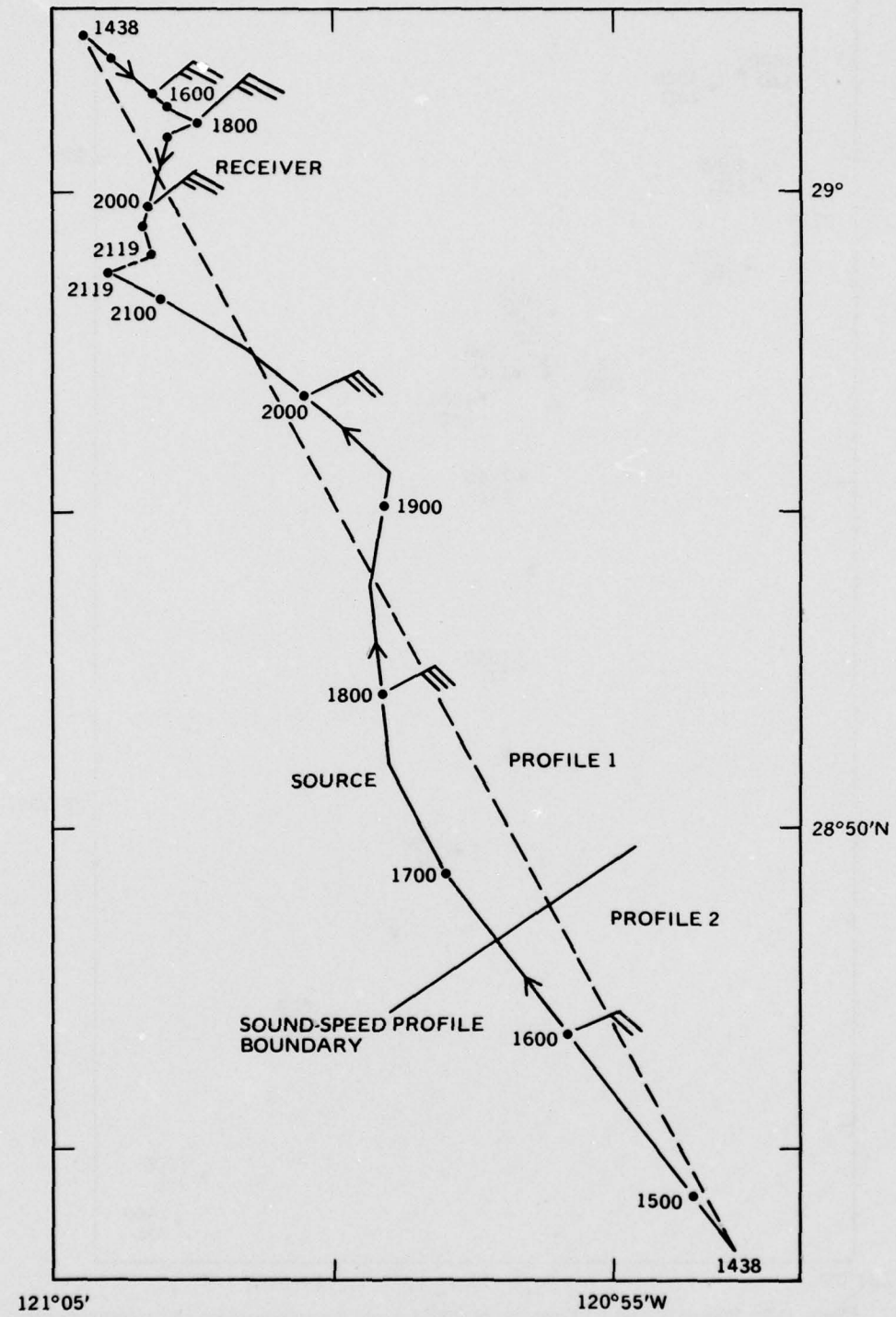

Figure D-1. Station 1, run 4. Location of source and receiver ships. 1438 and 2119 LST propagation paths (---), and wind velocity (10-knot east wind, 1 bar = 5 knots).

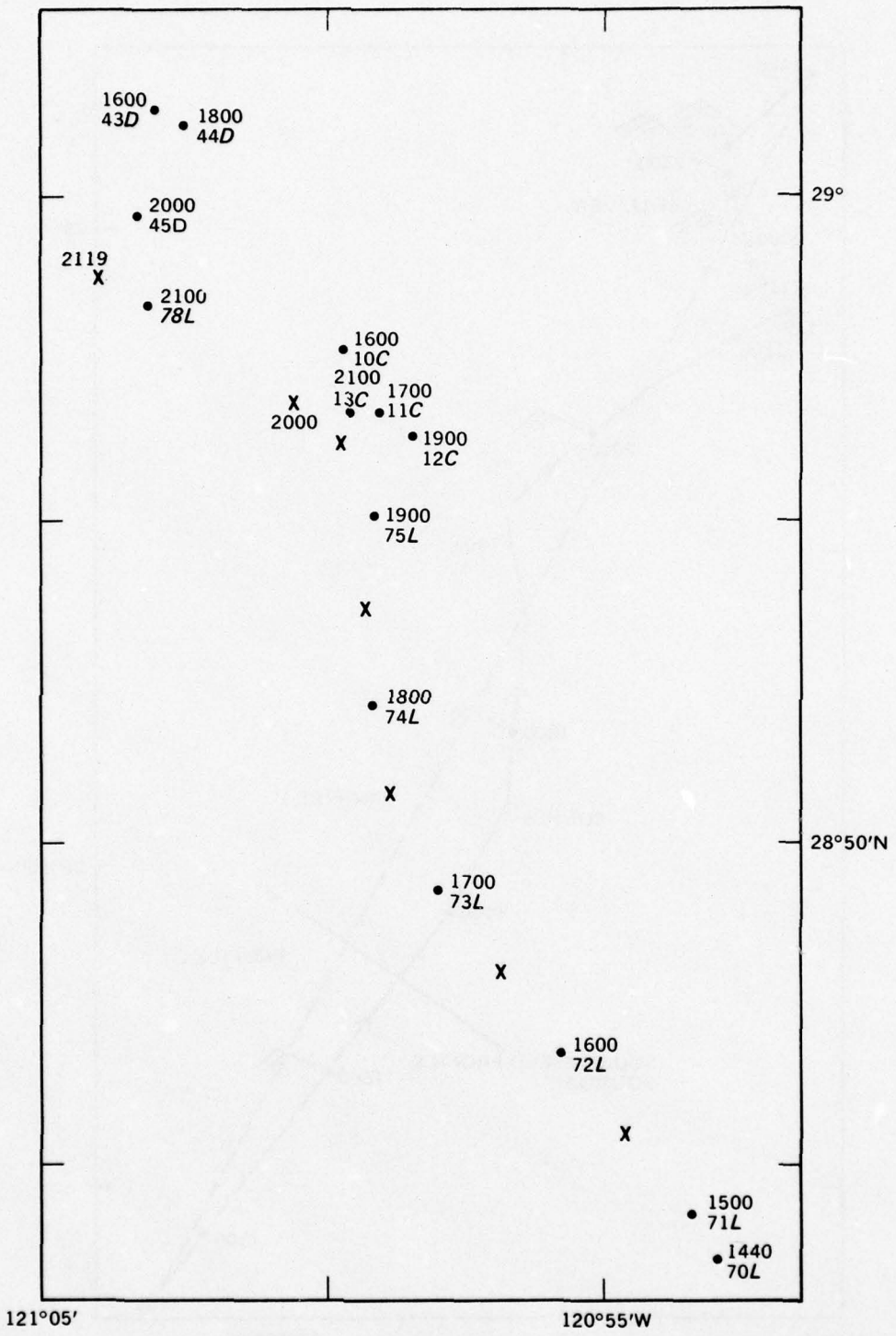

Figure D-2. Station 1, run 4. Location of XBT (·) and thermistor chain (X) measurements. The letter following the XBT number denotes the ship which took the measurement (*L:Lee, D:DeSteiguer, C:Cape*). The times shown are LST.

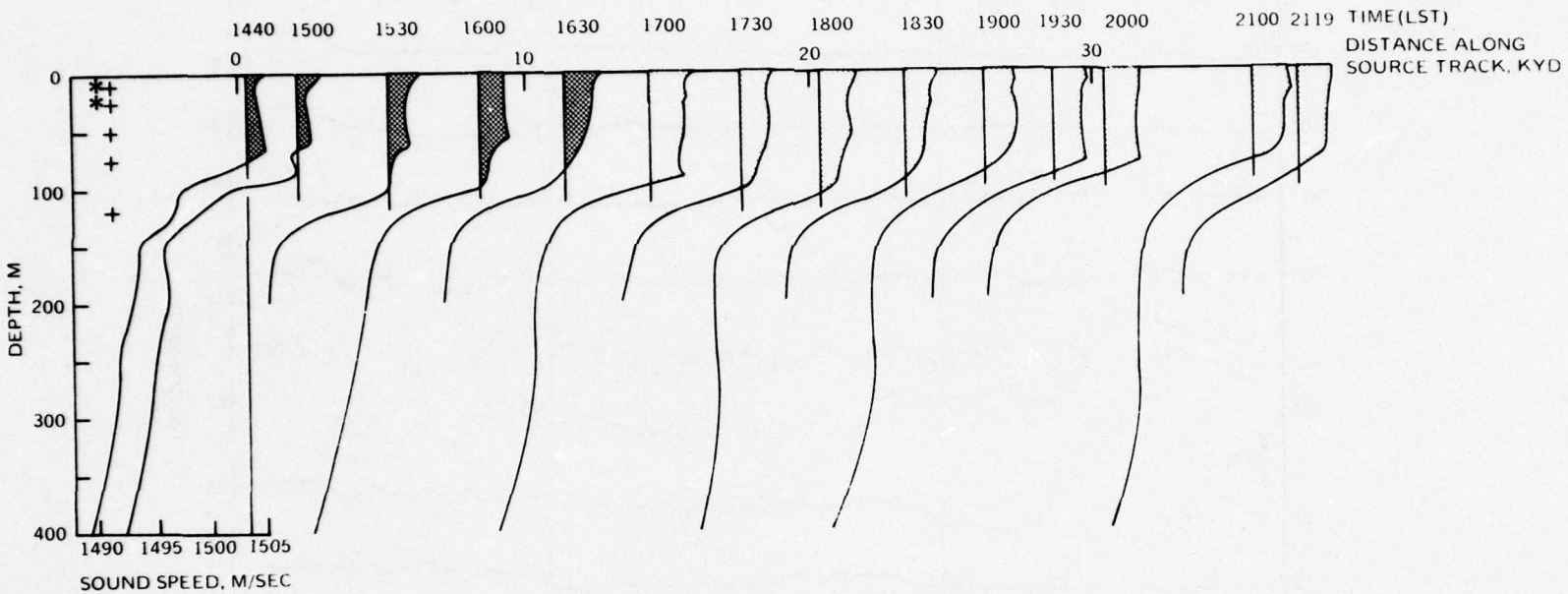

Figure D-3. Station 1, run 4. Sound-speed profiles along track of source ship derived from XBT and thermistor chain data. Source depth (*), receiver depths (+).

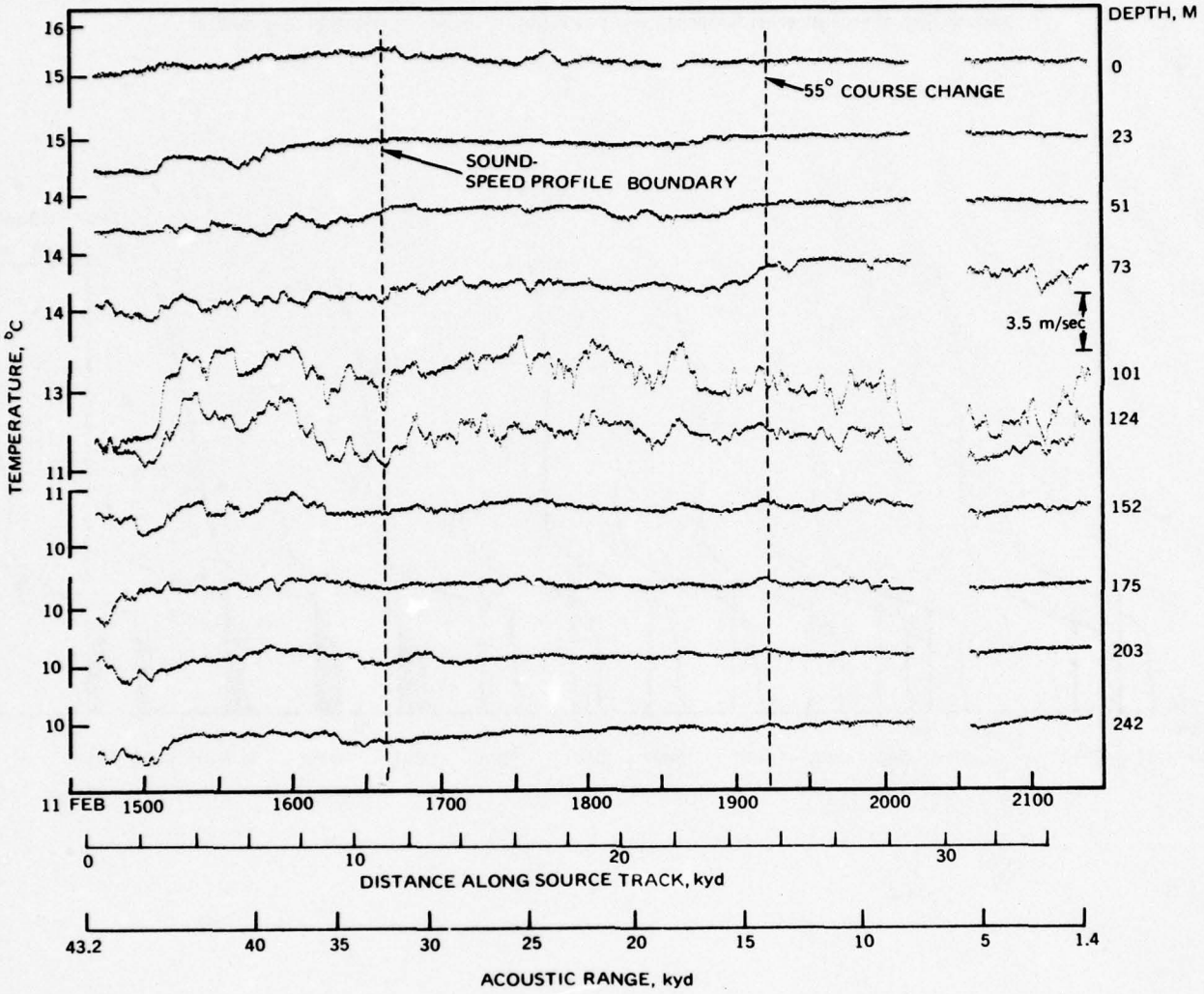

Figure D-4. Station 1, run 4. Thermistor chain temperature measurements at selected depths. Time is LST.

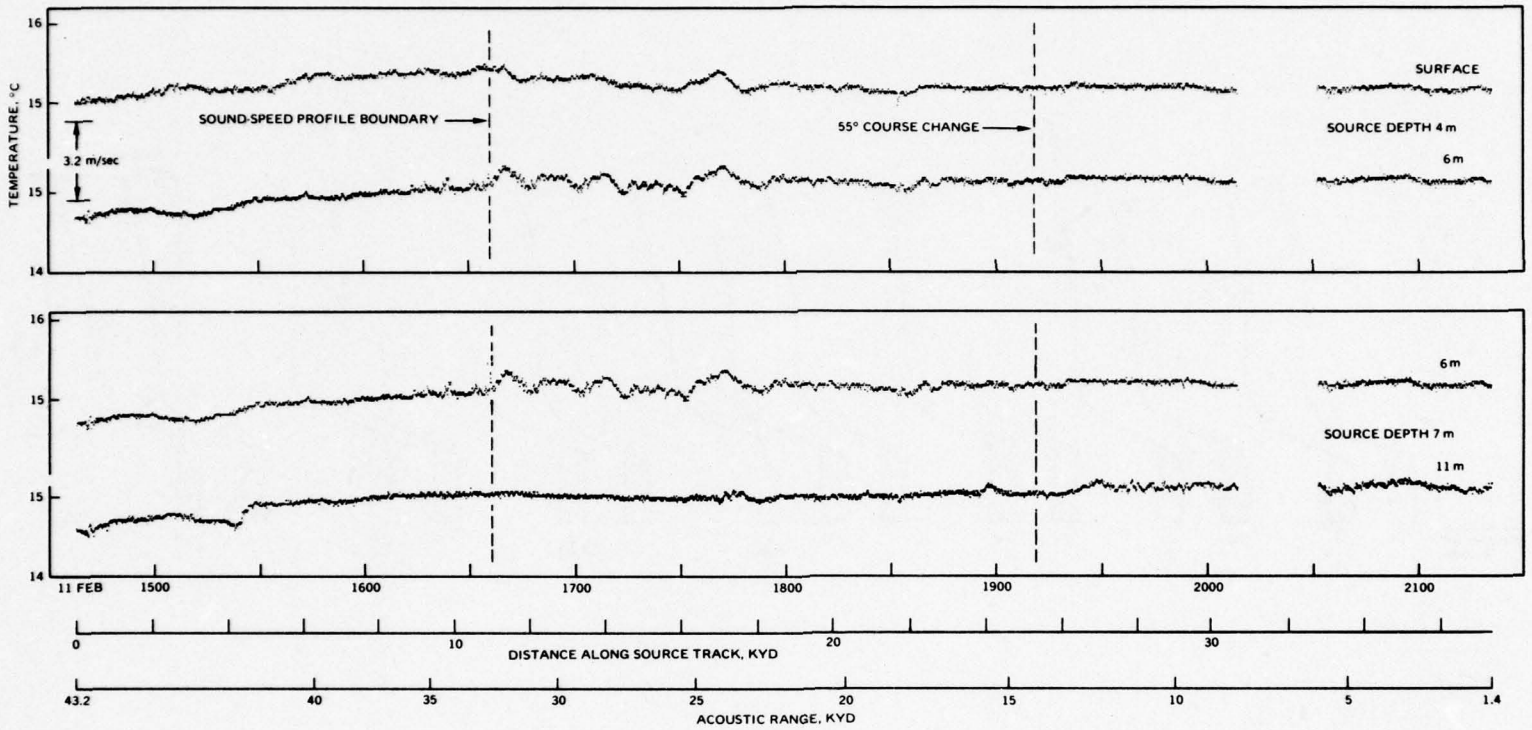

Figure D-5. Station 1, run 4. Temperatures above and below source.

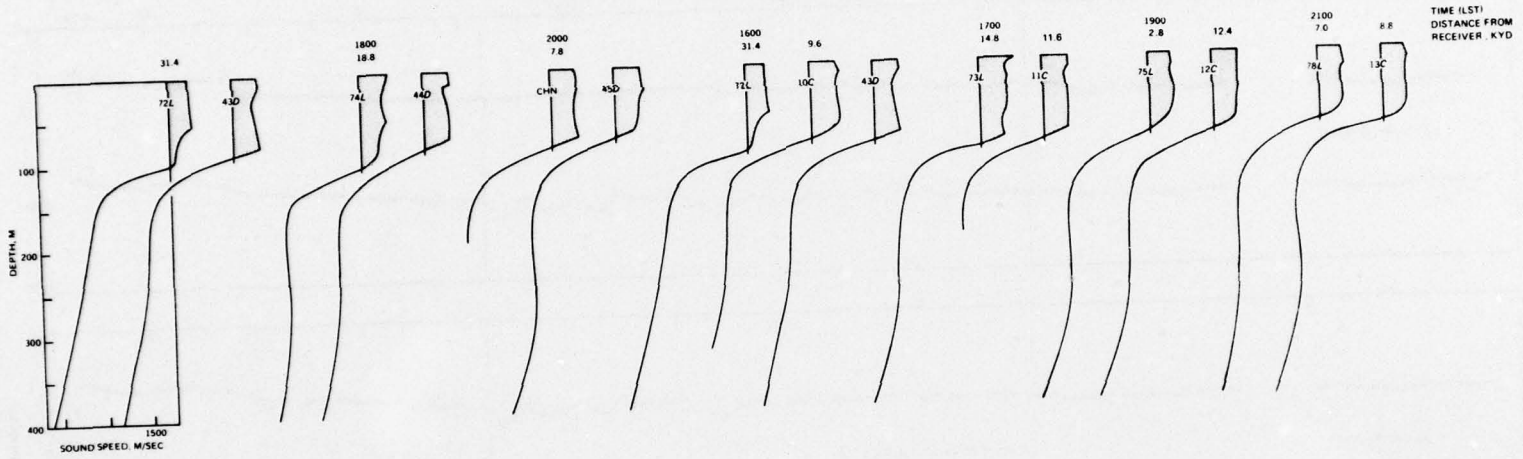

Figure D-6. Station 1, run 4. Spatial change in sound-speed profile.

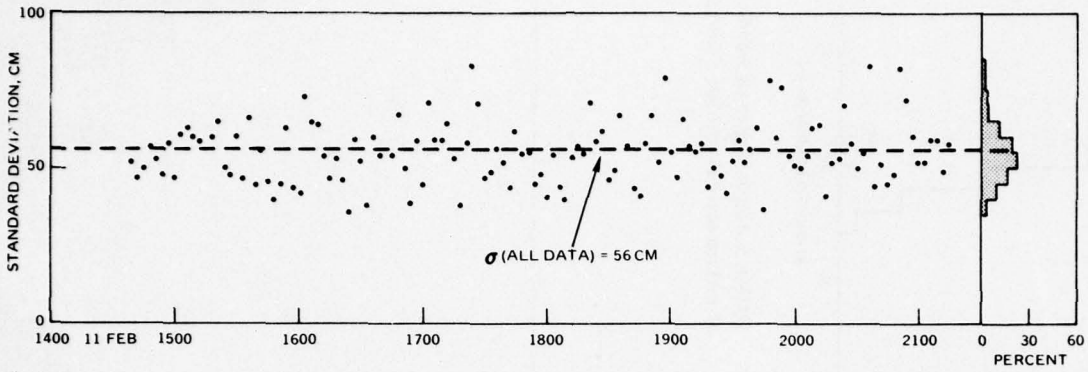

Figure D-7. Station 1, run 4. Standard deviation of surface-wave height for 3-min averages. Time is LST.

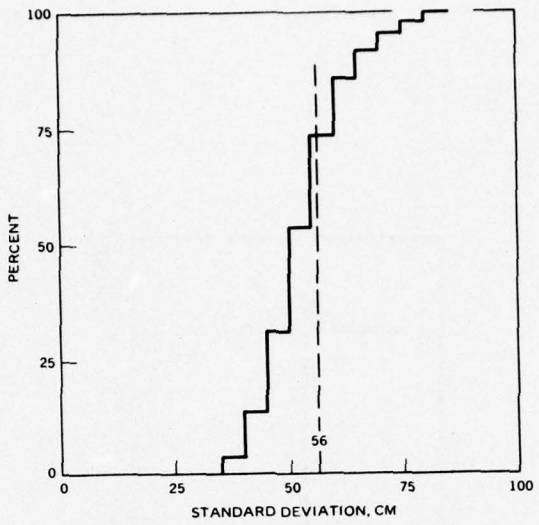

Figure D-8. Station 1, run 4. Ogive of standard deviation of surface-wave height for 3-min averages.

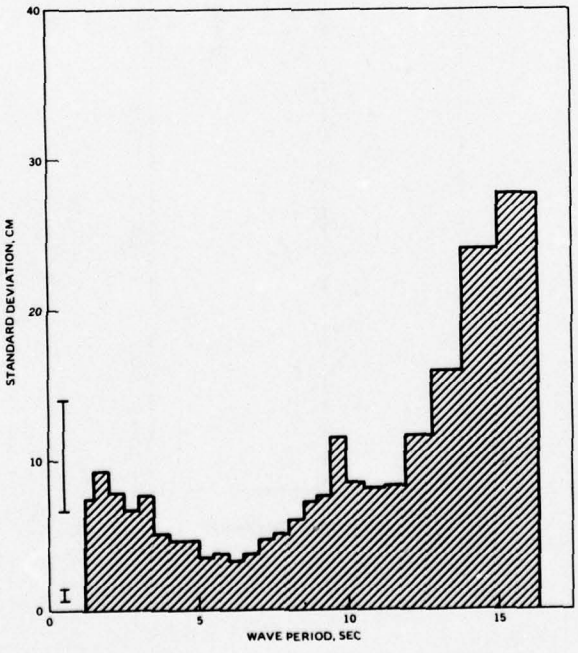

Figure D-9a. Station 1, run 4. Standard deviation of wave height as a function of wave period (11 February 1972, 1442-1537 LST).

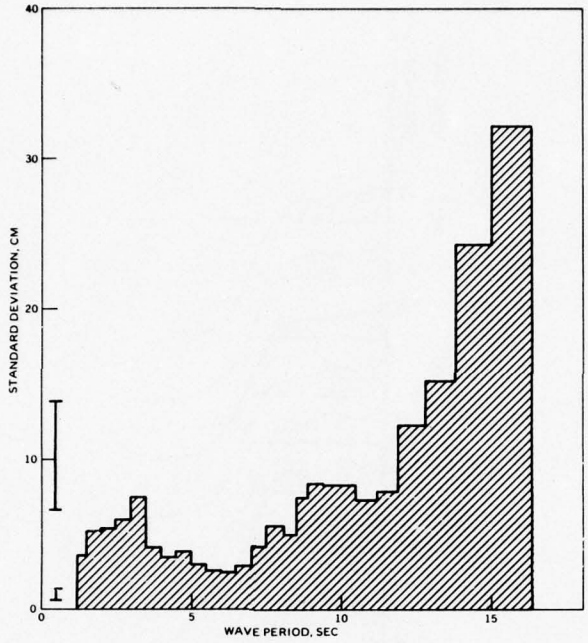

Figure D-9b. Station 1, run 4. Standard deviation of wave height as a function of wave period (11 February 1972, 1538-1825 LST).

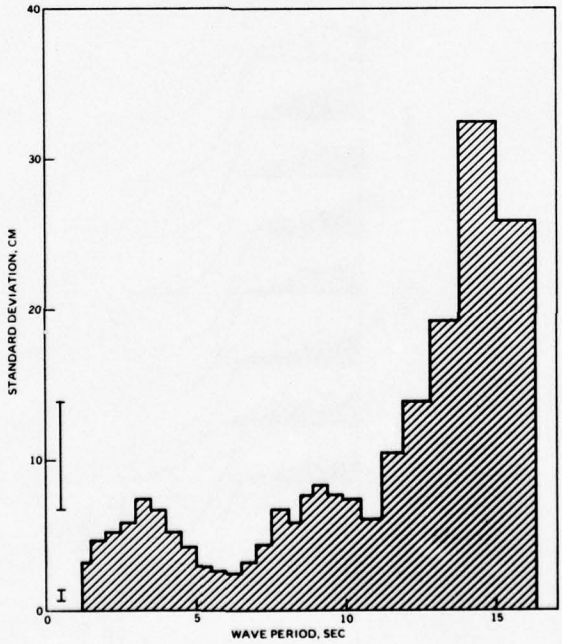

Figure D-9c. Station 1, run 4. Standard deviation of wave height as a function of wave period (11 February 1972, 1826-2113 LST).

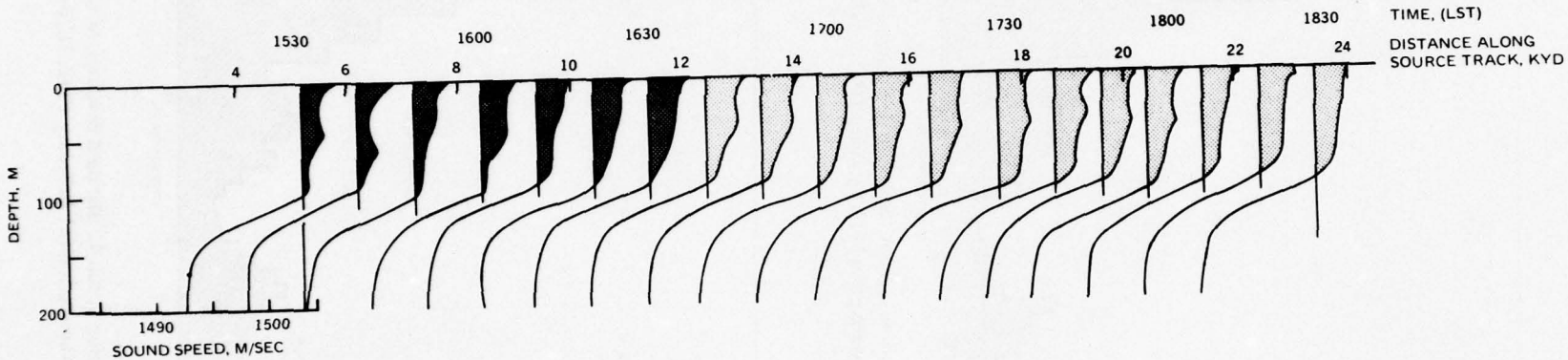

Figure D-10. Station 1, run 4. Expanded sound-speed profile plot.

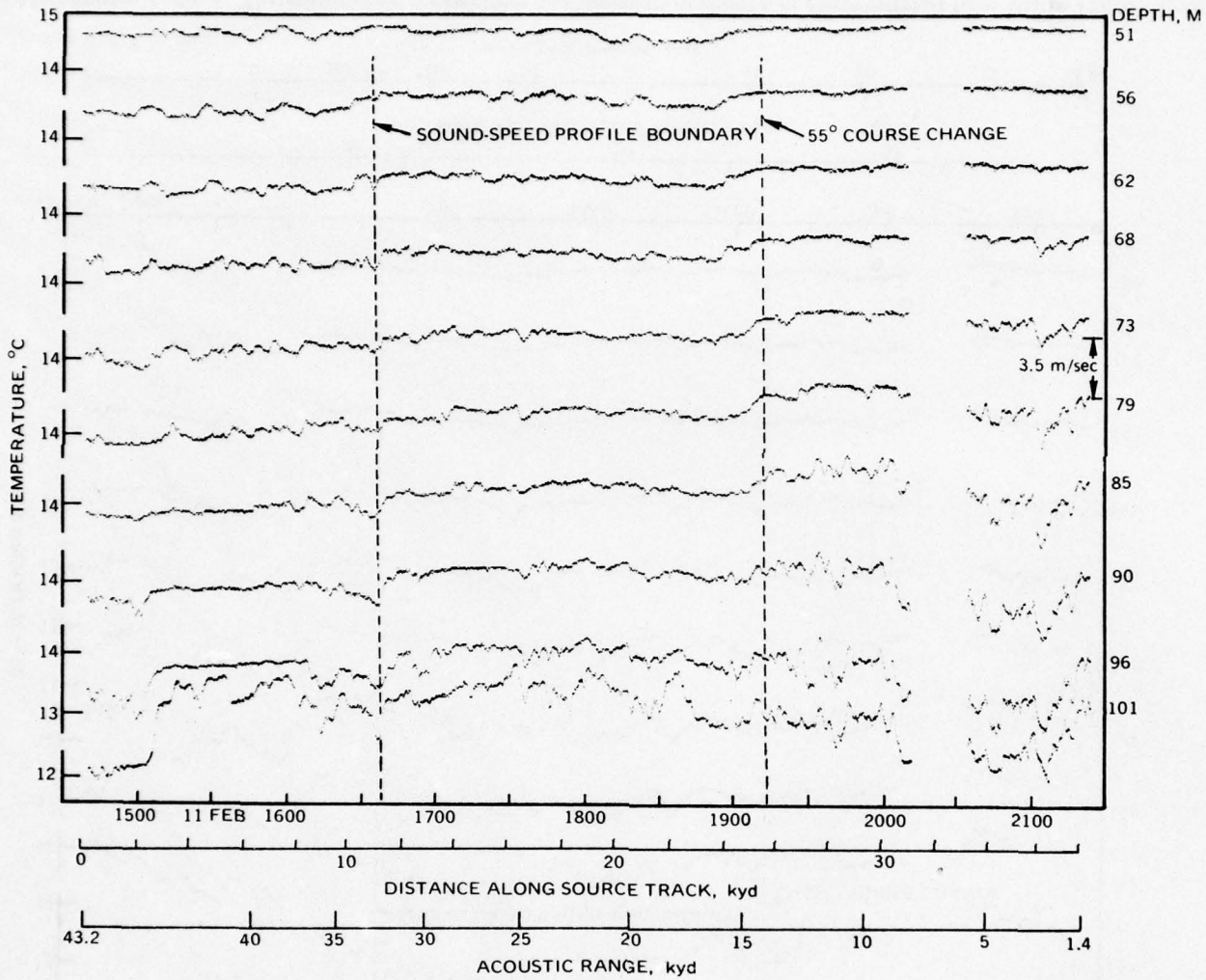

Figure D-11a. Station 1, run 4. Thermistor chain temperature measurements at about 6-m depth intervals from 51 to 101 m. Time is LST.

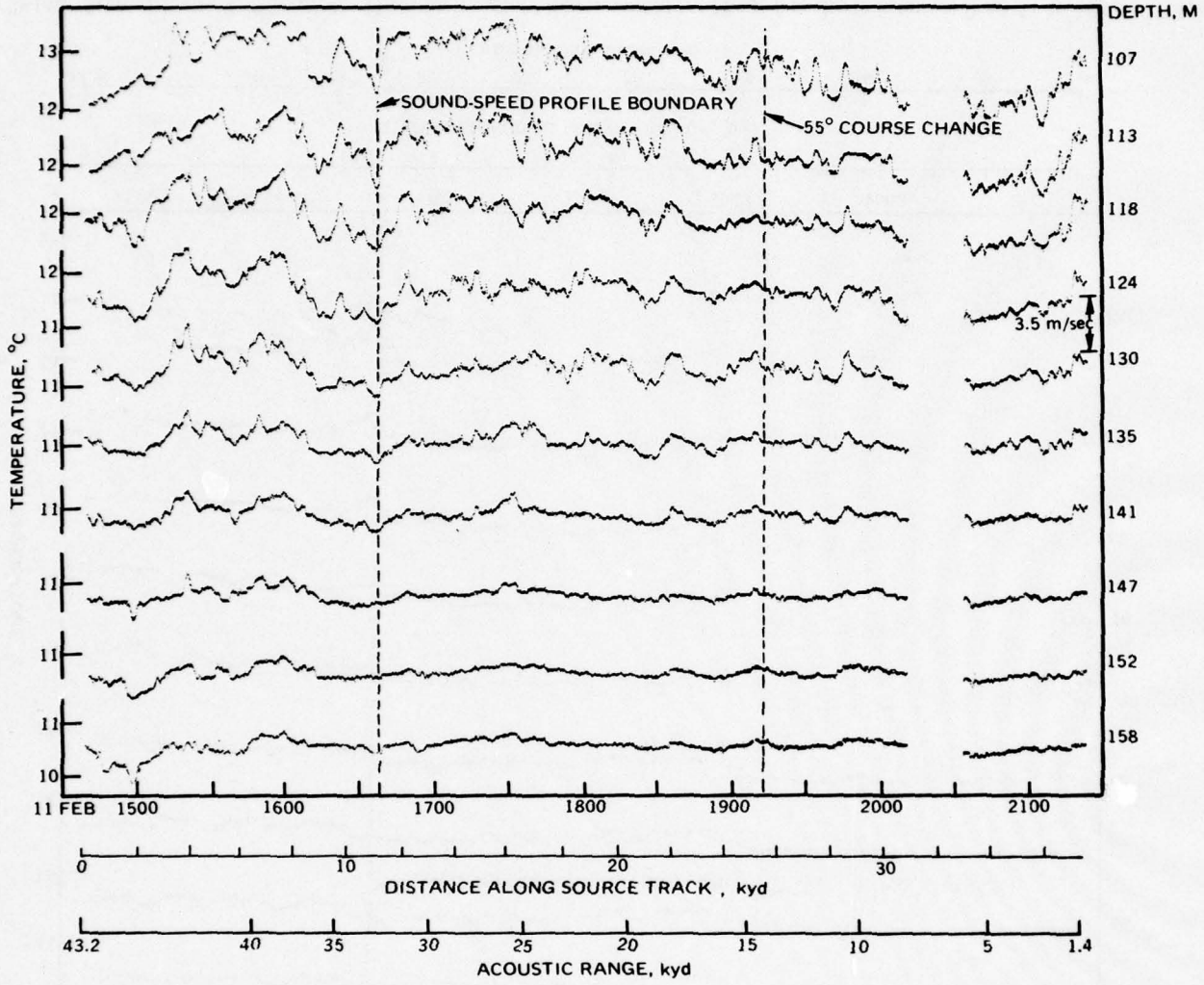

Figure D-11b. Station 1, run 4. Thermistor chain temperature measurements at about 6-m depth intervals from 107 to 158 m. Time is LST.

Table D-1. Temperature Profiles (°C),
Station 1 Run 4 (11 February 1972 1438-2119 LST).

XBT MEASUREMENTS

Depth, m	70L 1440	71L 1500	72L 1600	73L 1700	74L 1800	75L 1900	78L 2100
0	14.8	15.0	15.0	15.6	15.3	15.1	15.2
10	14.5	14.7	14.9	15.2	15.2	15.1	15.2
20	14.5	14.4	14.9	15.2	15.0	15.0	15.2
30	14.5	14.4	14.8	15.1	14.9	15.0	15.0
50	14.5	14.4	14.8	15.0	14.9	14.9	14.9
75	14.0	13.8	14.2	14.7	14.6	14.5	14.4
100	12.2	12.2	13.8	13.7	14.2	13.1	12.3
125	11.7	11.0	11.6	11.5	12.3	11.5	11.3
150	10.8	10.1	10.9	10.9	11.0	-0.8	10.7
200	10.3	9.9	10.3	10.3	10.5	10.3	10.3
250	9.6	9.3	9.7	9.9	10.2	10.0	9.9
300	9.2	8.8	9.1	9.5	9.9	9.5	9.6
400	8.1	7.8	7.9	8.3	8.9	8.2	8.5
ILD	0	0	0	0	0	10	20
T	14.8	15.0	15.0	15.6	15.3	15.1	15.2
SLD	65	88	97	90	97	59	68

Depth, m	43D 1600	44D 1800	45D 2000	10C 1600	11C 1700	12C 1900	13C 2100
0	15.2	15.2	15.2	15.2	15.2	15.2	15.1
10	15.2	15.2	15.2	15.3	15.2	15.2	15.1
20	15.0	14.9	15.2	15.2	15.0	15.1	15.0
30	14.8	14.9	15.1	15.1	15.0	15.1	14.9
50	14.8	14.9	14.9	15.0	14.9	14.9	14.8
75	14.8	14.8	14.4	14.8	14.8	14.7	14.6
100	12.9	13.0	12.4	12.8	13.4	13.0	12.0
125	11.4	11.5	11.2	11.1	11.5	11.3	11.0
150	10.7	10.7	10.7	10.6	10.8	10.7	10.6
200	10.2	10.1	10.2	10.2	10.3	10.2	10.1
250	9.8	9.8	9.9	9.8		9.8	9.9
300	9.2	9.4	9.6	9.2		9.4	9.5
400	8.1	8.3	8.3	8.0		8.0	8.2
ILD	10	15	25	0	10	15	10
T	15.2	15.2	15.2	15.2	15.2	15.2	15.1
SLD	82	77	68	76	80	60	75

Table D-1, continued.

THERMISTOR CHAIN MEASUREMENTS

Depth, m	1530	1540	1550	1600	1610	1620	1630	1640
0	15.2	15.3	15.4	15.3	15.4	15.4	15.4	15.5
10	14.9	14.9	14.9	15.0	15.0	15.0	15.1	15.1
20	14.7	14.7	14.8	14.9	14.9	15.0	15.0	15.0
30	14.6	14.5	14.8	14.8	14.8	14.9	14.9	15.0
50	14.5	14.4	14.4	14.7	14.5	14.6	14.7	14.8
75	14.1	14.2	14.2	14.1	14.3	14.3	14.2	14.3
100	13.8	13.5	13.8	13.8	13.4	13.5	13.3	13.4
125	11.8	11.8	12.2	11.8	11.4	11.4	11.3	11.4
150	10.7	10.7	10.9	10.9	10.8	10.6	10.6	10.6
200	10.2	10.3	10.4	10.3	10.3	10.3	10.1	10.2
ILD	0	0	0	0	0	0	0	0
T	15.2	15.3	15.4	15.3	15.4	15.4	15.4	15.5
SLD	85	96	96	96	85	79	96	90

Depth, m	1650	1700	1710	1720	1730	1740	1750	1800
0	15.3	15.3	15.3	15.2	15.2	15.4	15.2	15.3
10	15.0	15.0	15.1	15.0	15.0	15.1	15.0	15.0
20	15.0	15.0	14.9	14.9	14.9	14.9	14.9	14.9
30	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.8
50	14.8	14.7	14.8	14.8	14.8	14.8	14.8	14.8
75	14.3	14.4	14.4	14.4	14.5	14.4	14.4	14.4
100	13.4	13.5	13.8	13.7	14.0	13.7	13.5	13.9
125	11.6	11.5	11.7	11.5	11.7	11.8	11.6	12.0
150	10.7	10.7	10.7	10.8	10.8	10.8	10.8	10.7
200	10.2	10.1	10.1	10.1	10.2	10.2	10.2	10.2
ILD	0	0	6	0	0	0	6	0
T	15.3	15.3	15.2	15.2	15.2	15.2	15.2	15.3
SLD	90	90	96	96	90	85	96	96

Table D-1, continued.

Depth, m	1810	1820	1830	1930	2000	2119
0	15.2	15.2	15.2	15.2	15.2	15.2
10	15.0	15.0	15.0	15.2	15.2	15.1
20	14.9	14.9	14.9	15.0	15.1	15.0
30	14.8	14.8	14.9	15.0	15.0	14.9
50	14.6	14.7	14.6	14.8	14.9	14.8
75	14.3	14.4	14.4	14.8	14.8	14.6
100	13.6	13.4	13.6	13.0	13.0	13.3
125	11.7	11.6	11.6	11.5	11.4	11.7
150	10.7	10.6	10.7	10.6	10.7	10.7
200	10.1	10.2	10.2	10.1	10.2	10.2
ILD	6	6	0	0	17	6
T	15.2	15.2	15.2	15.2	15.1	15.2
SLD	96	79	79	79	79	68

Table D-2. Computed Sound-Speed Profiles (m/sec), Station 1 Run 4 (11 February 1972 1438-2119 LST).

XBT MEASUREMENTS

Depth, m	70L 1440	71L 1500	72L 1600	73L 1700	74L 1800	75L 1900	78L 2100
0	1504.7	1505.3	1505.3	1507.2	1506.3	1505.6	1506.0
10	03.9	04.5	05.2	06.1	06.1	05.8	06.1
20	04.0	03.7	05.3	06.3	05.6	05.6	06.3
30	04.2	03.9	05.2	06.1	05.5	05.8	05.8
50	04.5	04.2	05.5	06.2	05.8	05.8	05.8
75	03.2	02.6	03.9	05.6	05.2	04.9	04.6
100	1497.5	1497.5	03.1	02.7	04.4	00.7	1497.9
125	96.4	93.9	1496.0	1495.7	1498.5	1495.7	95.0
150	93.7	91.3	94.1	94.1	94.4	93.9	93.4
200	93.0	91.6	93.0	93.0	93.7	93.0	93.0
250	91.6	90.5	92.0	92.8	93.9	93.1	92.8
300	91.3	89.7	90.9	92.4	94.0	92.7	92.8
400	88.9	87.7	88.1	89.4	92.2	89.3	90.5
SC	0	0	0	0	0	10	20
DC	15	20	30	10	30	20	
MAX	65	60	55	25	55	30	
DC		70		80			
MAX		88		90			
RC		150			200	200	
MAX		200			300	250	

Table D-2, continued.

Depth, m	43D 1600	44D 1800	45D 2000	10C 1600	11C 1700	12C 1900	13C 2100
0	1506.0	1506.0	1506.0	1506.0	1506.0	1506.0	1506.0
10	06.1	06.1	06.1	06.4	06.1	06.1	05.8
20	05.6	05.3	06.3	06.3	05.6	06.0	05.6
30	05.2	05.5	06.1	06.1	05.8	06.1	05.5
50	05.5	05.8	05.8	06.2	05.8	05.8	05.5
75	05.9	05.9	04.6	05.9	05.9	05.6	05.2
100	00.0	00.3	1498.2	1499.6	01.7	00.3	1496.8
125	1495.3	1495.7	94.6	94.3	1495.7	1495.0	1493.9
150	93.4	93.4	93.4	93.0	93.7	93.4	93.0
200	92.6	92.3	92.6	92.6	93.0	92.6	92.3
250	92.4	92.4	92.8	92.4		92.4	92.8
300	91.3	92.0	92.8	91.3		92.0	92.4
400	88.9	89.7	89.7	88.5		88.5	89.3
SC	10	15	25	10	10	15	10
DC	30	20		30	20	20	
MAX	82	77		68	80	30	
RC		200	200				200
MAX		300	250				250

THERMISTOR CHAIN MEASUREMENTS

Depth, m	1530	1540	1550	1600	1610	1620	1630	1640
0	1506.0	1506.3	1506.6	1506.3	1506.5	1506.7	1506.6	1506.8
10	05.1	05.2	05.2	05.4	05.4	05.5	05.7	05.8
20	04.6	04.6	05.0	05.3	05.4	05.5	05.6	05.6
30	04.4	04.0	05.0	05.2	05.2	05.4	05.4	05.7
50	04.6	04.2	04.3	05.1	04.4	04.8	05.0	05.5
75	03.5	03.9	03.7	03.5	04.2	04.2	03.9	04.3
100	03.0	01.9	03.0	03.0	01.6	02.2	01.3	01.7
125	1496.9	1496.6	1498.0	1496.7	1495.3	1495.5	1495.0	1495.3
150	93.3	93.3	94.2	94.2	93.6	93.0	93.0	93.1
200	92.5	92.9	93.2	92.9	92.9	92.9	92.4	92.4
SC	0	0	0	0	0	0	0	0
DC	28	34						20
MAX	45	62						40

Table D-3. Average Sound-Speed Profiles (m/sec), Station 1 Run 4 (11 February 1972 1438–2119 LST).

Depth,	Profile 2 1438–1634			Profile 1 1636–2120		
m	2	$\bar{C}$	σ	n	$\bar{C}$	σ
0	702	1506.12	0.41	1575	1506.03	0.18
10	702	05.02	0.45	1575	05.76	0.23
20	702	04.79	0.62	1575	05.44	0.20
30	702	04.68	0.55	1575	05.52	0.20
50	702	04.52	0.33	1575	05.44	0.30
75	702	03.54	0.42	1575	04.94	0.57
100	702	01.37	2.07	1575	01.72	1.52
125	702	1496.04	1.37	1575	1494.81	0.57
150	702	93.27	0.57	1575	93.38	0.28
200	702	91.41	0.57	1575	92.56	0.18
250	702	91.81	0.65	1575	92.67	0.34
300	4	90.66	0.68	16	92.34	0.77
400	5	88.34	0.46	14	89.88	1.07
500	2	87.54	0.68	4	86.47	0.05
600	2	85.79	0.75	4	84.96	0.01
800	6	83.59	0.29			
1000	5	83.54	0.19			
1200	5	84.57	0.13			
1500	5	86.99	0.09			
20					1505.44	DC
30					1505.52	MAX
200					1492.56	RC
250					1492.67	MAX
900		1483.35			1483.35	AXIS

Table D-4. Average Thermistor Chain Temperatures, Station 1 Run 4 **Profile 1** (number of measurements at each depth: 1575).

Depth, m	Temperature, °C			Standard Deviation
	Min	Max	Mean	
0	14.97	15.50	15.22	0.067
6	14.90	15.35	15.16	0.059
11	14.90	15.22	15.04	0.068
17	14.77	15.15	14.99	0.051
23	14.77	15.10	14.95	0.060
28	14.72	15.05	14.92	0.060
34	14.70	15.00	14.89	0.057
39	14.70	15.00	14.88	0.059
45	14.57	15.00	14.84	0.071
51	14.47	14.90	14.76	0.088
56	14.50	14.92	14.76	0.106
62	14.42	14.90	14.70	0.125
68	13.97	14.90	14.62	0.150
73	14.17	14.90	14.53	0.176
79	13.75	14.92	14.45	0.215
85	13.22	14.87	14.27	0.247
90	12.92	14.50	14.00	0.316
96	12.55	14.32	13.77	0.379
101	11.95	13.95	13.11	0.441
107	11.65	13.55	12.70	0.433
113	11.42	13.00	12.23	0.353
118	11.22	12.40	11.85	0.262
124	11.02	12.02	11.58	0.209
130	10.80	11.85	11.26	0.164
135	10.67	11.40	11.01	0.123
141	10.57	11.27	10.86	0.097
147	10.37	11.02	10.77	0.075
152	10.37	10.80	10.64	0.075
158	10.35	10.80	10.59	0.081
164	8.45	10.70	10.52	0.085
169	10.22	10.70	10.45	0.066
175	10.20	10.55	10.38	0.055
180	10.17	10.50	10.34	0.044
186	10.12	10.40	10.27	0.041
192	10.12	10.37	10.24	0.043
197	10.07	10.32	10.19	0.045
203	10.02	10.30	10.16	0.050
209	9.95	10.25	10.11	0.051
214	9.87	10.20	10.07	0.061
220	9.85	10.20	10.05	0.071
226	9.77	10.17	9.99	0.083
231	9.70	10.12	9.92	0.090
237	9.67	10.10	9.91	0.089
242	9.62	10.07	9.89	0.085

Table D-4, continued. **Profile 2** (number of measurements at each depth: 702).

Depth, m	Temperature, °C Min	Max	Mean	Standard Deviation
0	15.00	15.47	15.25	0.127
6	14.62	15.20	14.90	0.130
11	14.50	15.10	14.85	0.148
17	14.37	15.05	14.77	0.188
23	14.35	15.00	14.70	0.193
28	14.32	14.95	14.66	0.182
34	14.37	14.90	14.63	0.162
39	14.37	14.87	14.62	0.148
45	14.32	14.80	14.57	0.130
51	14.30	14.70	14.47	0.096
56	14.32	14.75	14.50	0.085
62	14.30	14.70	14.47	0.077
68	14.17	14.52	14.33	0.077
73	13.82	14.35	14.13	0.124
79	13.80	14.30	14.02	0.124
85	13.72	14.17	13.90	0.096
90	13.32	13.97	13.78	0.131
96	12.72	13.92	13.62	0.282
101	11.90	13.80	13.10	0.577
107	11.87	13.47	12.75	0.438
113	11.67	13.05	12.43	0.319
118	11.35	12.77	12.04	0.370
124	11.07	12.40	11.67	0.385
130	10.77	12.10	11.62	0.297
135	10.65	11.60	11.06	0.209
141	10.55	11.30	10.89	0.188
147	10.35	11.17	10.77	0.154
152	10.17	10.95	10.60	0.160
158	9.90	10.85	10.51	0.183
164	9.82	10.70	10.41	0.196
169	9.77	10.60	10.37	0.207
175	9.70	10.57	10.36	0.163
180	9.70	10.55	10.35	0.142
186	9.75	10.50	10.27	0.148
192	9.90	10.50	10.23	0.173
197	9.82	10.42	10.16	0.166
203	9.70	10.40	10.11	0.161
209	9.60	10.30	10.04	0.166
214	9.52	10.25	9.98	0.165
220	9.55	10.20	9.93	0.159
226	9.42	10.10	9.84	0.169
231	9.35	10.02	9.76	0.161
237	9.35	9.95	9.75	0.156
242	9.30	9.92	9.70	0.168

Table D-5. Standard Deviation (cm) of Wave Height for 3-Min Averages, Station 1 Run 4 (11 February 1972 1438–2119 LST).

	Hours							
Minutes	1400	1500	1600	1700	1800	1900	2000	2100
02		61	73	71	54	47	50	52
05		63	65	59	44	66	54	59
08		60	64	51	40	57	63	51
11		59	54	64	53	56	64	49
14		56	47	53	57	58	41	58
17		60	53	38	55	44	52	
20		65	46	58	71	50	53	
23		50	36	83	59	48	70	
26		48	59	71	62	42	58	
29		60	52	47	46	52	50	
32		47	38	49	49	59	55	
35		66	60	56	67	52	83	
38	52	45	54	52	57	56	44	
41	47	56	47	44	43	63	51	
44	50	46	54	62	41	37	45	
47	57	40	67	55	58	78	48	
50	53	45	50	55	67	60	82	
53	48	63	39	45	52	76	72	
56	58	44	59	48	79	54	60	
59	47	42	45	41	55	51	52	

Table D-6. Standard Deviation of Wave Height as a Function of Wave Period, Station 1 Run 4 (11 February 1972).

Wave-Period Band, sec	Standard Deviation, cm	Wave-Period Band, sec	Standard Deviation, cm
1442–1537 LST			
1.2 – 1.4	7.4	7.5 – 7.9	5.1
1.5 – 1.9	9.3	8.0 – 8.4	6.0
2.0 – 2.4	7.8	8.5 – 8.8	7.2
2.5 – 2.9	6.7	8.9 – 9.3	7.6
3.0 – 3.4	7.6	9.4 – 9.8	11.5
3.5 – 3.9	5.1	9.9 – 10.4	8.5
4.0 – 4.4	4.7	10.5 – 11.1	8.2
4.5 – 4.9	4.7	11.2 – 11.8	8.3
5.0 – 5.4	3.5	11.9 – 12.7	11.6
5.5 – 5.9	3.7	12.8 – 13.7	15.9
6.0 – 6.4	3.3	13.8 – 14.9	24.1
6.5 – 6.9	3.7	15.0 – 16.2	27.7
7.0 – 7.4	4.7		
1538–1825 LST			
1.2 – 1.4	3.6	7.5 – 8.0	5.6
1.5 – 1.9	5.2	8.1 – 8.4	5.0
2.0 – 2.4	5.4	8.5 – 8.8	7.5
2.5 – 2.9	6.0	9.9 – 9.3	8.4
3.0 – 3.4	7.5	9.4 – 9.8	8.3
3.5 – 3.9	4.2	9.9 – 10.4	8.3
4.0 – 4.4	3.5	10.5 – 11.1	7.3
4.5 – 4.9	3.9	11.2 – 11.8	7.9
5.0 – 5.4	3.0	11.9 – 12.7	12.3
5.5 – 5.9	2.6	12.8 – 13.7	15.2
6.0 – 6.4	2.5	13.8 – 14.9	24.3
6.5 – 6.9	2.9	15.0 – 16.2	32.1
7.0 – 7.4	4.3		
1826–2113 LST			
1.2 – 1.4	3.2	7.5 – 8.0	6.7
1.5 – 1.9	4.7	8.1 – 8.4	5.9
2.0 – 2.4	5.2	8.5 – 8.8	7.7
2.5 – 2.9	5.8	8.9 – 9.3	8.3
3.0 – 3.4	7.4	9.4 – 9.8	7.7
3.5 – 3.9	6.7	9.9 – 10.4	7.4
4.0 – 4.4	5.2	10.5 – 11.1	6.1
4.5 – 4.9	4.2	11.2 – 11.8	10.5
5.0 – 5.4	2.9	11.9 – 12.7	13.9
5.5 – 5.9	2.6	12.8 – 13.7	19.3
6.0 – 6.4	2.5	13.8 – 14.9	32.5
6.5 – 6.9	3.2	15.0 – 16.2	25.9
7.0 – 7.4	4.4		

APPENDIX E

STATION 1 RUN 5

DETAILED ENVIRONMENTAL DATA

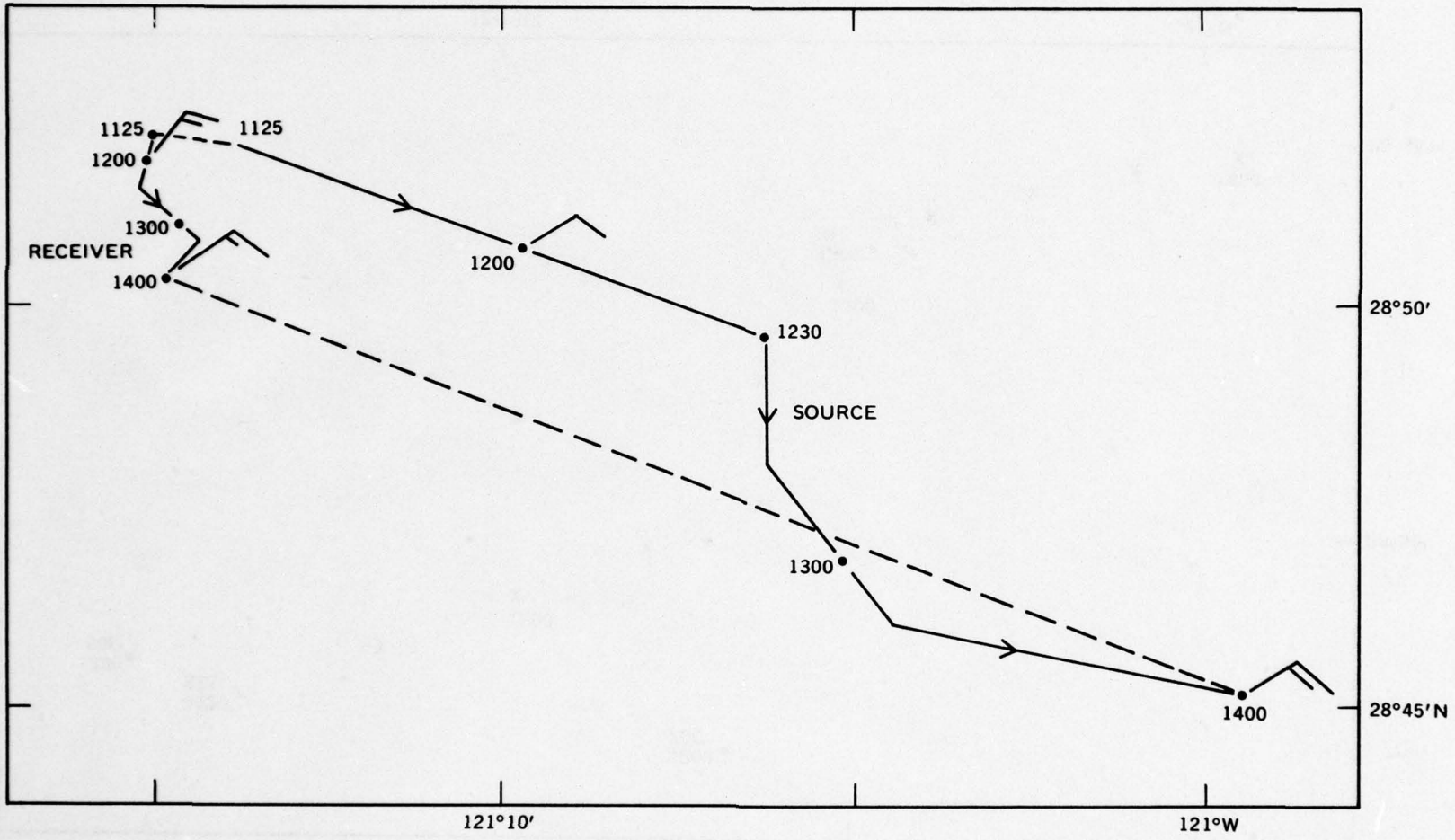

Figure E-1. Station 1, run 5. Location of source and receiver ships, 1125 and 1400 LST propagation paths (---), and wind velocity (⚑ 10-knot east wind, 1 bar = 5 knots).

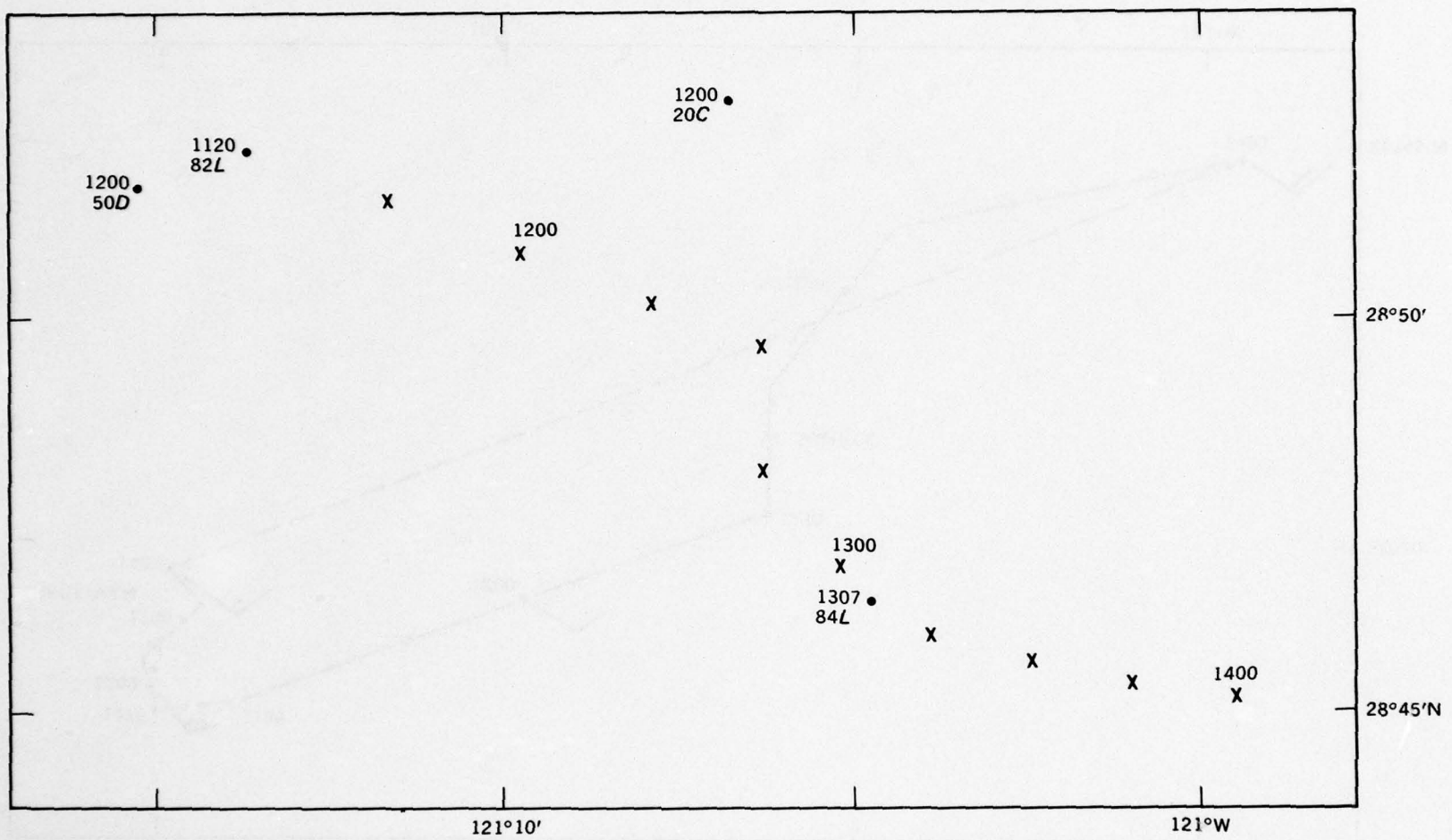

Figure E-2. Station 1, run 5. Location of XBT (•) and thermistor chain (X) measurements. The letter following the XBT number denotes the ship which took the measurement (*L:Lee, D:DeSteiguer, C:Cape*). The times shown are LST.

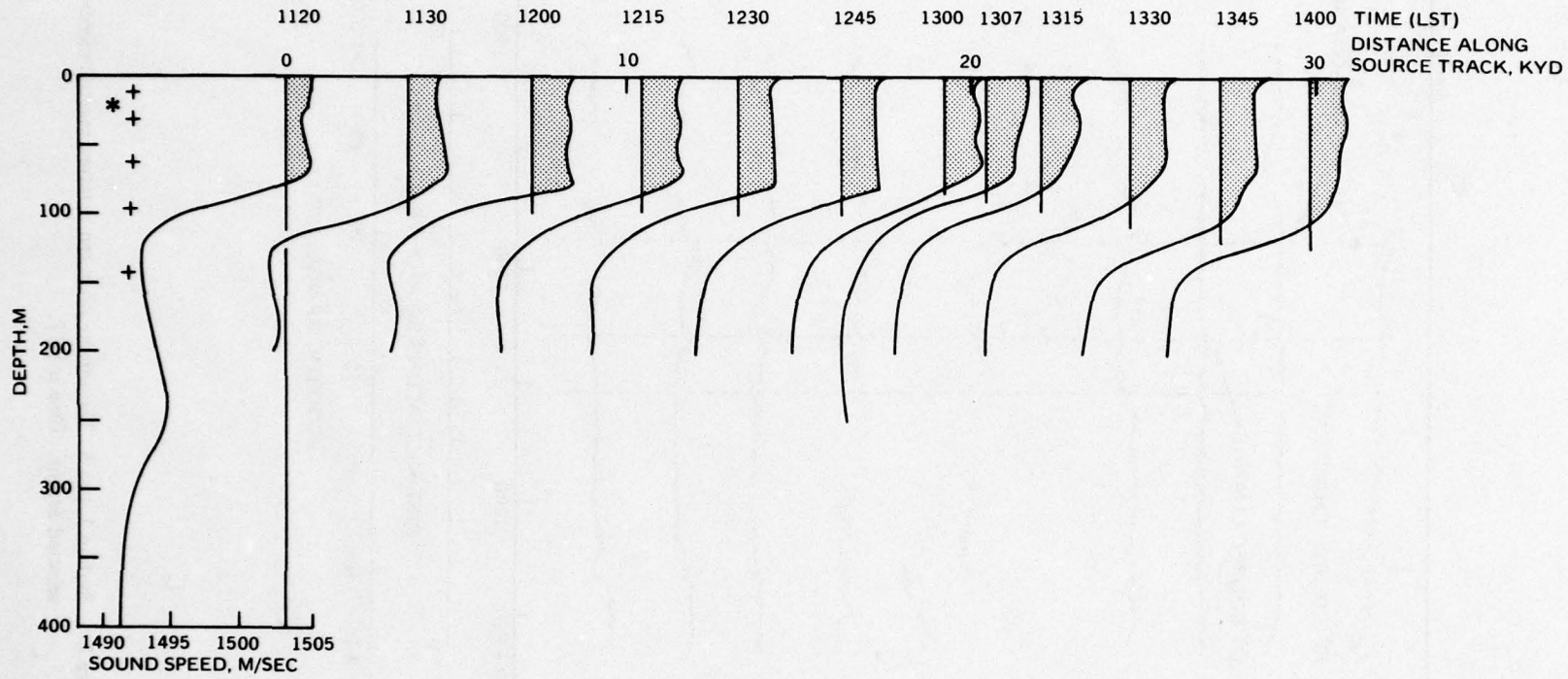

Figure E-3. Station 1, run 5. Sound-speed profiles along track of source ship derived from XBT and thermistor chain data. Source depth (*), receiver depths (+).

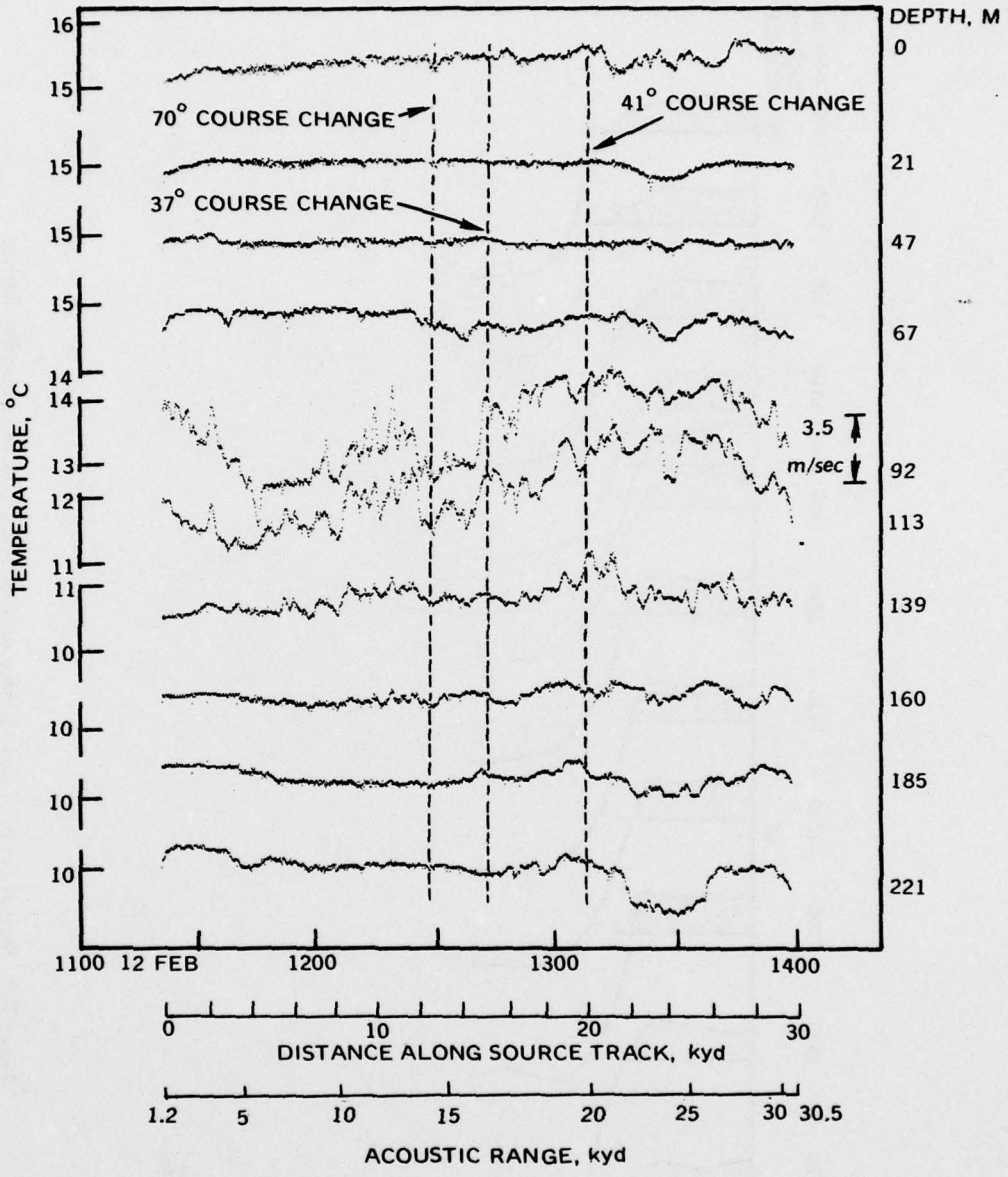

Figure E-4. Station 1, run 5. Thermistor chain temperature measurements at selected depths. Time is LST.

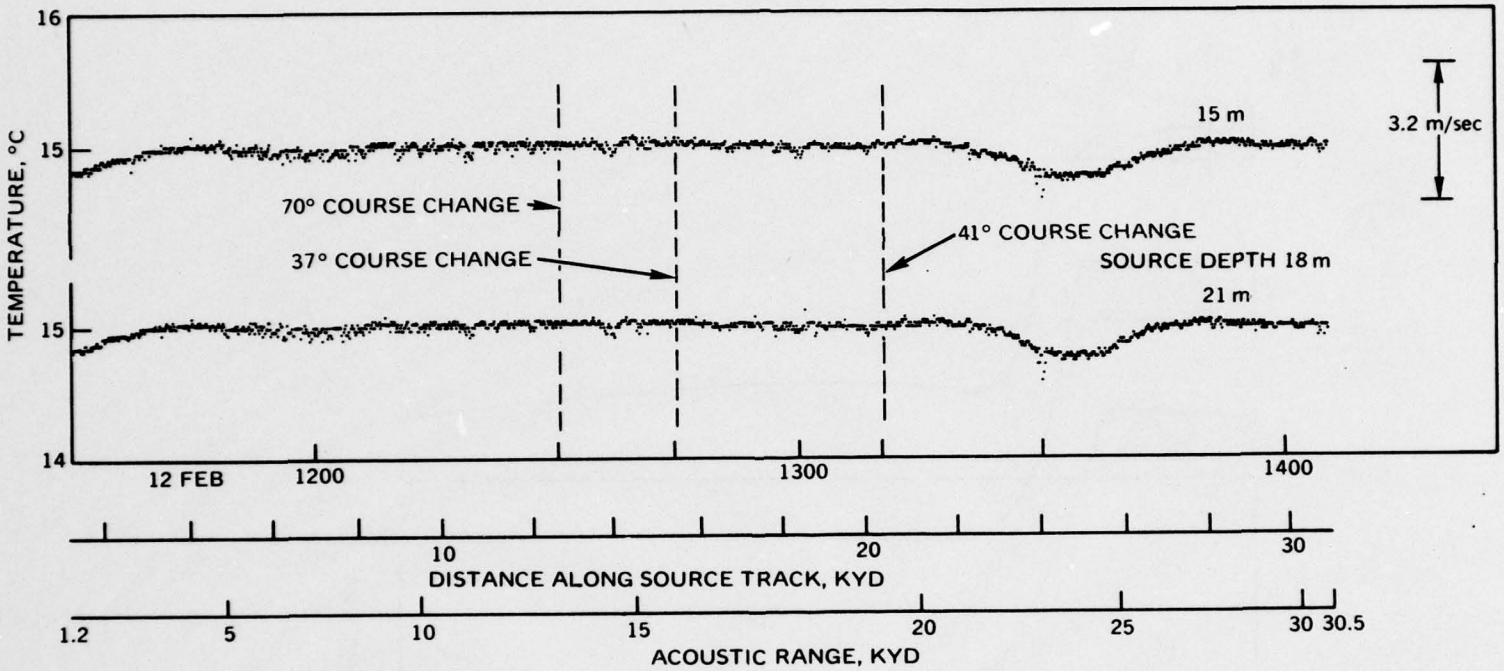

Figure E-5. Station 1, run 5. Temperatures above and below source. Time is LST.

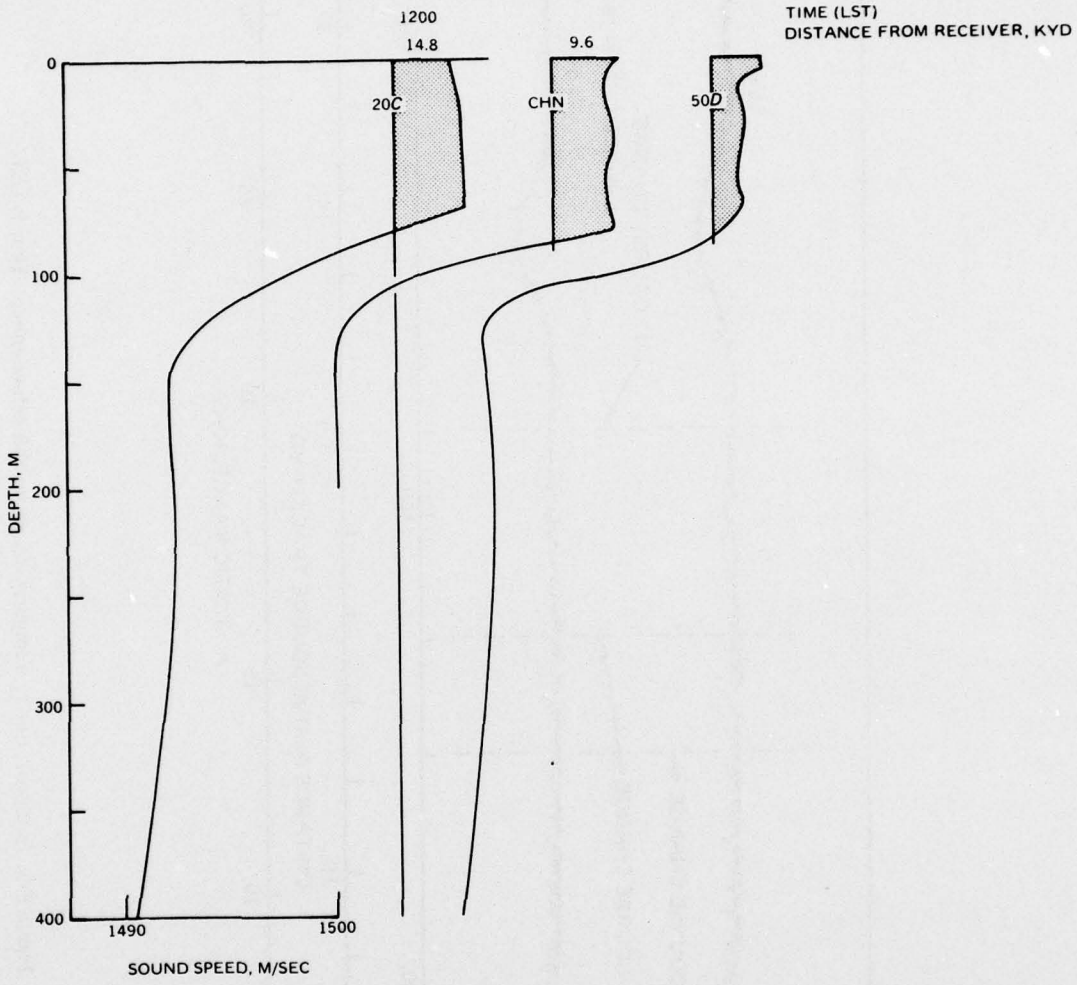

Figure E-6. Station 1, run 5. Spatial change in sound-speed profile.

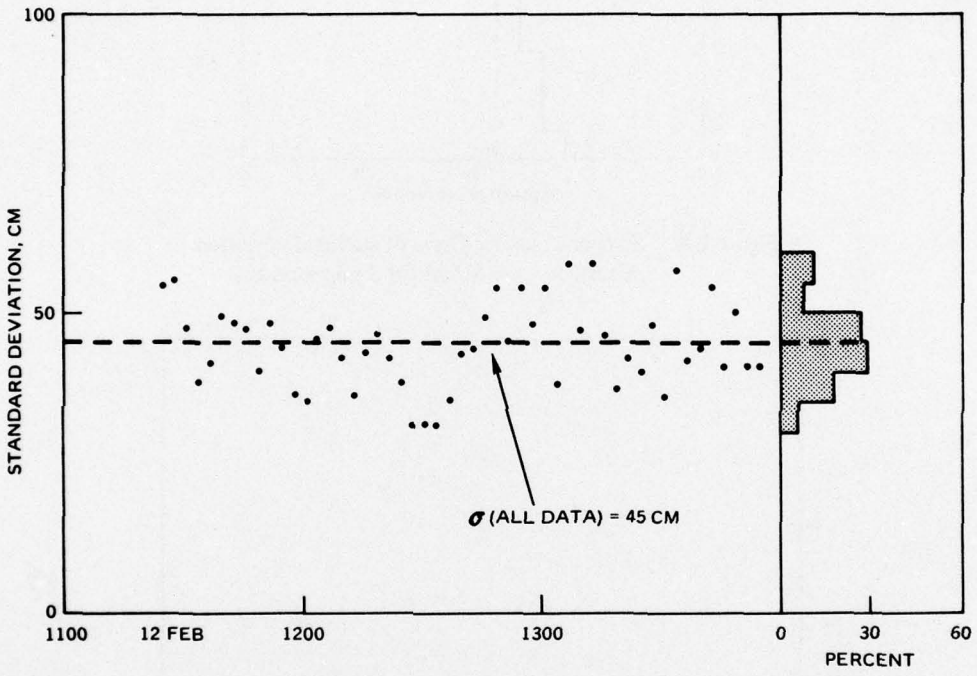

Figure E-7. Station 1, run 5. Standard deviation of surface-wave height for 3-min averages. Time is LST.

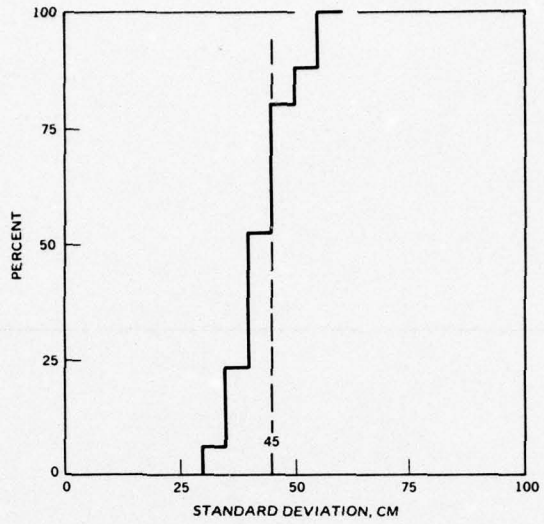

Figure E-8. Station 1, run 5. Ogive of standard deviation of surface-wave height for 3-min averages.

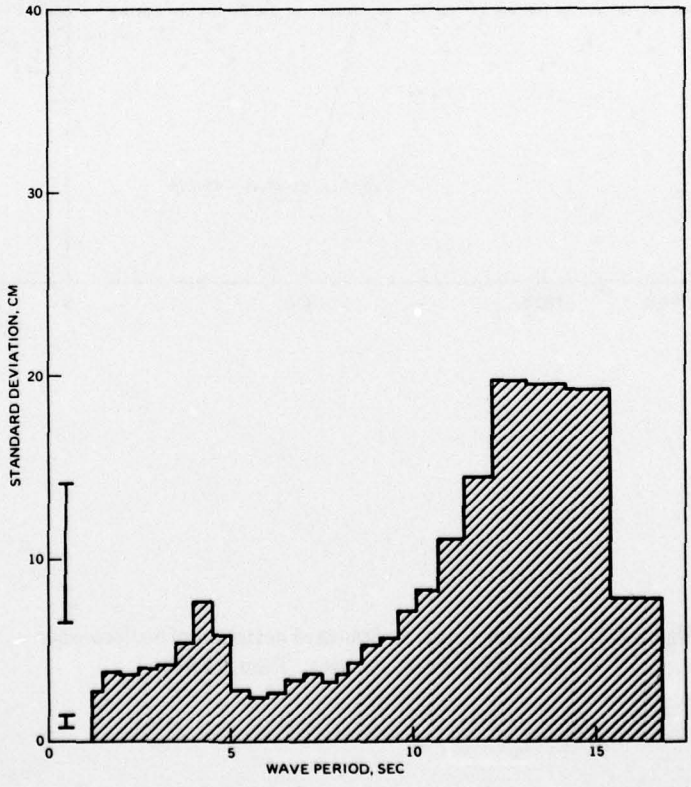

Figure E-9. Station 1, run 5. Standard deviation of wave height as a function of wave period (12 February 1972, 1127-1356 LST).

Table E-1. Temperature Profiles (°C),
Station 1 Run 5 (12 February 1972 1125-1400 LST).

	XBT MEASUREMENTS				THERMISTOR CHAIN MEASUREMENTS		
Depth, m	82L 1120	84L 1307	50D 1200	20C 1200	1130	1200	1215
0	14.9	15.2	15.0	15.1	15.0	15.3	15.3
10	14.8	15.2	14.7	15.1	14.9	15.0	15.0
20	14.7	15.1	14.6	15.1	14.8	15.0	15.0
30	14.5	15.0	14.6	15.1	14.8	15.0	15.0
50	14.5	14.7	14.4	15.0	14.8	14.8	14.8
75	14.2	14.4	14.3	14.4	14.6	14.7	14.7
100	11.6	12.2	12.6	12.3	13.0	11.9	12.5
125	10.6	11.2	10.5	11.0	10.8	10.8	11.1
150	10.5	10.7	10.4	10.4	10.6	10.5	10.5
200	10.5	10.1	10.2	10.2	10.4	10.2	10.2
250	9.8	9.9	9.8	9.8			
300	9.4		9.4	9.4			
400	8.6		8.6	8.5			
ILD	0	10	8	30	0	0	0
T	14.9	15.2	15.0	15.1	15.0	15.3	15.3
SLD	80	66	91	68	72	78	72

	THERMISTOR CHAIN MEASUREMENTS						
Depth, m	1230	1245	1300	1315	1330	1345	1400
0	15.3	15.4	15.2	15.4	15.4	15.5	15.2
10	15.0	15.0	14.9	15.0	15.0	15.0	15.0
20	14.9	15.0	14.9	15.0	15.0	15.0	15.0
30	14.9	14.9	14.9	15.0	14.9	14.9	15.0
50	14.8	14.8	14.8	14.8	14.8	14.8	14.8
75	14.7	14.8	14.3	14.3	14.4	14.6	14.6
100	12.4	12.7	12.5	12.5	13.3	14.0	14.0
125	11.0	11.3	11.1	11.0	11.3	12.2	12.1
150	10.4	10.6	10.5	10.6	10.6	10.9	10.7
200	10.1	10.1	10.0	10.1	10.2	10.3	10.2
ILD	0	0	0	0	0	0	0
T	15.3	15.4	15.2	15.4	15.4	15.5	15.2
SLD	78	78	67	47	47	67	72

Table E-2. Computed Sound-Speed Profiles (m/sec), Station 1 Run 5 (12 February 1972 1125-1400 LST).

	XBT MEASUREMENTS				THERMISTOR CHAIN MEASUREMENTS		
Depth, m	82L 1120	84L 1307	50D 1200	20C 1200	1130	1200	1215
0	1505.0	1406.0	1505.6	1505.3	1505.3	1506.1	1506.2
10	04.8	06.1	05.8	04.5	05.0	05.5	05.5
20	04.7	06.0	06.0	04.3	05.0	05.5	05.5
30	04.2	05.8	06.1	04.5	05.1	05.7	05.7
50	04.5	05.2	06.2	04.2	05.5	05.5	05.5
75	03.9	04.6	04.6	04.2	05.2	05.5	05.6
100	1495.4	1497.5	1497.9	1498.9	00.2	1496.6	1498.6
125	92.5	94.6	93.9	92.2	1493.1	93.1	94.1
150	92.7	93.4	92.3	92.3	92.9	92.7	92.6
200	93.7	92.3	92.6	92.6	93.2	92.7	92.6
250	92.4	92.8	92.4	92.4			
300	92.0		92.0	92.0			
400	91.0		90.5	91.0			
SC	0	10	68	8	0	0	0
DC	30			20	15	15	15
MAX	65			30	72	30	30
DC						55	41
MAX						78	72
RC	125	200	150	125	144	144	160
MAX	200	250	200	150	185	185	msg

Table E-2, continued.

THERMISTOR CHAIN MEASUREMENTS

Depth, m	1230	1245	1300	1315	1330	1345	1400
0	1506.3	1506.5	1506.0	1506.7	1506.5	1506.8	1506.0
10	05.3	05.5	05.2	05.5	05.5	05.5	05.4
20	05.4	05.6	05.4	05.6	05.5	05.5	05.5
30	05.6	05.6	05.6	05.8	05.5	05.6	05.7
50	05.6	05.6	05.4	05.5	05.5	05.6	05.4
75	05.6	05.8	04.1	04.3	04.6	05.1	05.1
100	1498.1	1499.3	1498.6	1498.6	01.4	03.8	03.8
125	94.0	94.9	94.1	93.9	1494.9	1498.1	1497.9
150	92.4	93.1	92.7	93.0	92.9	94.1	93.4
200	92.3	92.4	91.9	92.4	92.5	93.1	92.7
SC	0	0	0	0	0	0	0
DC	15	10	10	10	10	10	10
MAX	78	78	31	47	57	67	36
DC			47				
MAX			67				
RC	154						
MAX	191						

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Table E-3. Average Sound-Speed Profile (m/sec), Station 1 Run 5 (12 February 1972 1125-1400 LST).

Depth, m	Number of Observations	Average Speed	Standard Deviation
0	2421	1506.16	0.36
10	2421	05.54	0.23
20	2421	05.54	0.20
30	2421	05.56	0.20
50	2421	05.44	0.33
75	2421	04.94	0.90
100	2421	1499.11	1.54
125	2421	94.18	0.95
150	2421	92.82	0.39
200	2421	92.34	0.43
250	10	92.74	0.32
300	9	92.36	0.47
400	7	90.44	0.86
500	4	87.54	0.68
600	4	85.79	0.75
800	6	83.59	0.29
1000	5	84.54	0.19
1200	5	84.57	0.13
1500	5	86.66	0.09
15		1505.52	DC
36		1505.58	MAX
200		1492.34	RC
250		1492.74	MAX
900		1483.40	AXIS

Table E-4. Average Thermistor Chain Temperatures, Station 1 Run 5 (number of measurements at each depth: 2421).

Depth, m	Temperature, °C Min	Max	Mean	Standard Deviation
0	14.87	15.62	15.26	0.107
6	14.72	15.35	15.11	0.091
10	14.77	15.22	15.02	0.067
16	14.72	15.15	14.98	0.052
21	14.67	15.10	14.96	0.058
26	14.67	15.05	14.94	0.060
31	14.70	15.02	14.90	0.060
36	14.70	15.02	14.90	0.061
41	14.57	15.00	14.85	0.068
47	14.47	14.95	14.79	0.082
51	14.50	14.97	14.78	0.096
57	14.42	14.92	14.74	0.119
62	13.97	14.92	14.68	0.147
67	14.17	14.90	14.60	0.183
72	13.75	14.92	14.54	0.226
78	13.22	14.87	14.38	0.266
82	12.92	14.82	14.10	0.326
88	12.55	14.70	13.85	0.394
92	11.95	14.40	13.20	0.504
98	11.65	14.22	12.80	0.488
103	11.42	13.82	12.36	0.443
108	11.22	13.30	11.97	0.376
113	11.02	12.87	11.68	0.333
119	10.90	12.62	11.37	0.312
103	10.72	12.30	11.13	0.281
129	10.65	12.07	10.96	0.236
134	10.37	11.82	10.84	0.191
139	10.37	11.47	10.68	0.148
144	10.35	11.30	10.62	0.124
150	8.45	10.92	10.54	0.106
154	10.22	10.80	10.47	0.083
160	10.20	10.70	10.40	0.074
164	10.17	10.70	10.36	0.071
170	10.12	10.62	10.30	0.071
175	10.10	10.60	10.27	0.075
180	10.07	10.55	10.23	0.086
*185	10.02	10.55	10.21	0.096
191	9.95	10.50	10.17	0.101
195	9.90	10.47	10.13	0.111
201	9.90	10.45	10.11	0.116
216	9.82	10.40	10.05	0.119
211	9.75	10.35	9.98	0.120
216	9.75	10.32	9.97	0.116
221	9.72	10.30	9.94	0.108

*2420 measurements at this depth.

Table E-5. Standard Deviation (cm) of Wave Height for 3-Min Averages, Station 1 Run 5 (12 February 1972 1125-1400 LST).

Minutes	Hours 1100	1200	1300
01		35	54
04		45	38
07		47	58
10		42	47
13		36	58
16		43	46
19		46	37
22		42	42
25	54	38	40
28	55	31	48
31	47	31	36
34	38	31	57
37	41	35	42
40	49	43	44
43	48	44	54
46	47	49	41
49	40	59	50
52	48	45	41
55	44	54	41
58	36	48	

Table E-6. Standard Diviation of Wave Height as a Function of Wave Period, Station 1 Run 5 (12 February 1972 1125-1400 LST).

Wave-Period Band, sec	Standard Deviation, cm	Wave-Period Band, sec	Standard Deviation, cm
1.2 – 1.4	2.8	7 5 – 7.8	3.2
1.5 – 1.9	3.8	7.9 – 8.1	3.6
2.0 – 2.4	3.7	8.2 – 8.5	4.3
2.5 – 2.9	4.0	8.5 – 9.0	5.3
3.0 – 3.4	4.2	9.1 – 9.5	5.6
3.5 – 3.9	5.4	9.6 – 10.0	7.1
4.0 – 4.4	7.6	10.1 – 10.6	8.2
4.2 – 4.9	5.8	10.7 – 11.3	11.0
5.0 – 5.4	2.8	11.4 – 12.1	14.4
5.5 – 5.9	2.4	12.2 – 13.0	19.7
6.0 – 6.4	2.6	13.1 – 14.1	19.5
6.5 – 6.9	3.3	14.2 – 15.3	19.3
7.0 – 7.4	3.7	15.4 – 16.7	7.8